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SPECIFICATION

DEVICE AND METHOD FOR MANUFACTURING THREAD LINE

TECHNICAL FIELD

The present invention relates to a method and apparatus for producing a yarn consisting of numerous filaments, comprising the steps of discharging a flowable polymer from numerous spinning holes formed in a spinneret, to form the numerous filaments, letting the formed numerous filaments pass through a filament passage satisfying specific gas stream conditions of a spinning tube installed below the spinneret, taking up the numerous filaments coming out of the filament passage, and winding the numerous filaments.

A typical example of the polymer used in the yarn production method is a polyester polymer (e.g., polyethylene terephthalate). Furthermore, the yarn production method can also be preferably used for producing a partially oriented yarn.

BACKGROUND ART

For producing a yarn, especially a partially oriented yarn (POY) of a polyester or the like, generally an apparatus shown in Fig. 1 is used. In Fig. 1, a spinneret 1 has numerous spinning holes 6. Numerous filaments F discharged from the spinning holes 6 are cooled and solidified by means of cooling air 3a supplied

by a cooling means 3. The solidified numerous filaments F are taken up by a godet roller 4, to form a yarn Y. The yarn Y consisting of the numerous filaments F is wound around a bobbin by a winder 5, to produce a yarn package.

To enhance yarn production efficiency, it is generally attempted to raise a yarn production speed. In the case where the apparatus shown in Fig. 1 is used, if the yarn take-up speed of a godet roller 4 is raised, the take-up tension T acting on the filaments F upstream of the godet roller 4 increases. As a result, the elongation of the produced yarn Y declines. That is, for example, if a yarn of polyethylene terephthalate is produced at a take-up speed of 3,000 m/min, the elongation of the produced yarn becomes 135%. If the take-up speed is increased to 4,000 m/min, the elongation of the yarn becomes 90%, and if the take-up speed is increased to 5,000 m/min, the elongation of the yarn becomes 65%. At a higher take-up speed, the elongation of the produced yarn becomes lower.

Furthermore, in the apparatus shown in Fig. 1, a circular spinneret 1 shown in Fig. 2 is used. The spinneret 1 has numerous spinning holes 6. The polymer discharged from the numerous spinning holes 6 forms numerous filaments F. The numerous filaments F run downward. To the running numerous filaments F, cooling air 3a is supplied from one side only. Especially when the take-up speed is high, the volume of the cooling air 3a is also increased. Therefore, the filaments F swing very greatly. Furthermore, since the distances of the respective numerous

filaments F from a cooling means 3 are different, the respective filaments F are cooled in different conditions. The yarn Y consisting of the numerous filaments F produced in this way has filament irregularity.

As described above, it is difficult to produce a yarn at a higher take-up speed for achieving a higher production efficiency with the yarn elongation kept at the same level as achieved at a low take-up speed without causing any difference among the filaments constituting the yarn (without causing filament irregularity).

An attempt to overcome the difficulty for obtaining a high elongation yarn at a high speed is described in US-A-5,824,248. The outline of the attempt is shown in Fig. 3. The spinning apparatus shown in Fig. 3 has a cylindrical cooling means 55 and a tube 73 having a diameter smaller than that of the cylindrical cooling means 55 below a spinneret 1. Cooling air 55a of the cylindrical cooling means 55 generates a descending air stream in the tube 73 positioned downstream of it. It is proposed to impart an air stream in the tube 73 to the numerous filaments F discharged from the numerous spinning holes 6 of the spinneret 1.

JP-A-08-506393 proposes to adjust a flow velocity of an air stream flowing in a tube to a velocity equal to a running speed of the polymer, for decreasing a take-up tension T acting on the filaments. It is described that this constitution allows a yarn to be produced stably even if a take-up speed of the yarn is kept

high.

However, in these methods, like the apparatus shown in Fig. 1, a polymer is discharged from the numerous spinning holes 6 formed in the circular spinneret 1 shown in Fig. 2, to form numerous filaments F. Therefore, the distances of the respective numerous filaments F from the cylindrical cooling means 55 are different. Furthermore, due to the difference in diameter between the cylindrical cooling means 55 and the tube 73, the cooling air 55a becomes different in its state between the outside and the inside of the numerous filaments. Therefore, the outside running filaments F are different in cooling state from the inside running filaments F. The yarn Y consisting of the numerous filaments F produced in this way has filament irregularity.

JP-A-2001-262427 proposes to inject a heating fluid from heating fluid injection holes formed around the spinning holes of the spinneret obliquely downward to the running filaments. It is intended that the filaments discharged from the spinning holes are kept at a high temperature and made thinner by means of the heating fluid flow. It is described that with this constitution, even if the spinning speed is raised, that is, even if the filament take-up speed is raised, a high elongation yarn can be obtained. Furthermore, it is described that if a suction means is installed downstream of the heating fluid injection holes, the discharged filaments can be made thinner more positively.

However, in this spinning apparatus, the heating fluid injected from the heating fluid injection holes flows toward the

suction means. So, there is a problem that the heating medium heats the suction means. Furthermore, there is another problem that the heating fluid introduced into the suction means destabilizes temperature of a gas stream running in the suction means. The unstable temperature condition affects the filaments running in the suction means. The yarn produced after undergoing this condition has filament irregularity.

Moreover, since the heating fluid injection holes are formed directly in the spinneret, the injected heating fluid does not have an established passage on the discharge face of the spinning holes of the spinneret, and is merely released into the space between the spinneret and the suction means. For this reason, between the central portion and the end portions of the numerous spinning holes arranged along straight lines, a problem arises that force of the heating fluid acting on the filaments becomes different. The yarn consisting of numerous filaments produced like this has filament irregularity.

On the other hand, it can happen that a gas is generated from the polymer flow as just discharged from the spinning holes of the spinneret. The gas contains low polymerization products of the intended polymer, i.e., the monomer, oligomer (hereinafter called a volatile substance), etc. The volatile substance is deposited on the spinneret face and its vicinity. The deposit causes the filaments to be broken during spinning. If a filament is broken, the spinning work must be suspended to correct the trouble, disturbing the continuous operation of spinning process. Such

a gas is generated not only in the case where polyethylene terephthalate is spun, but also in the case where another polymer is spun. Especially, thermally decomposable polymers such as polyamides, polypropylene and aliphatic polyesters (polylactic acid, etc.) generate the gas in a large amount. The deposition of the volatile substance caused by the generated gas disturbs the continuous operation of spinning process.

JP-B-50-13924 and JP-A-9-250022 respectively disclose a device for sucking a gas generated below the spinneret. The device sucks the gas from lateral sides of the polymer flow (filaments F) as just discharged the spinning holes of the spinneret.

However, according to the suction method, in the case where the filaments F are discharged from the numerous spinning holes substantially uniformly distributed in the circular spinneret shown in Fig. 2, only the gas existing near the filaments F positioned outside can be sufficiently sucked. Therefore, the gas existing near the filaments positioned inside cannot be sufficiently removed. There occurs a state where the running filaments F entrain the gas, to carry it in the running direction of the filaments F.

Also in the spinning process disclosed in US-A-5,824,248 mentioned above, the gas is generated below the spinneret. However, in this case, since the cylindrical cooling means 55 keeps the area below the spinneret 1 gas-tight, the cooling air 55a supplied from it carries the gas containing the volatile substance toward the tube 73 positioned downstream and is discharged from the bottom end of the tube 73. Therefore, no gas remains near the spinneret

face, and the adhesion of the deposit to the spinneret face caused by the gas is hard to occur. So, in such a spinning apparatus, it is not necessary to install the suction means as described in JP-B-50-13924 or JP-A-09-250022 mentioned above for decreasing the contamination of the spinneret face.

On the other hand, US-A-5,824,248 mentioned above proposes that the inner diameter of the tube should be 25 mm or more. Therefore, in this spinning apparatus, since a tube having a large inner diameter is used, even if the volatile substance in the passing gas is deposited on the inner wall of the tube, it does not affect the filaments running in the tube.

The object of the invention is to overcome the above-mentioned problems of the prior art, by providing a method and apparatus for producing a yarn free from irregularity and having a high elongation even if the speed for taking up the numerous filaments is raised.

DISCLOSURE OF THE INVENTION

The present invention provides a method for producing a yarn consisting of numerous filaments, using:

(a) a spinneret having numerous spinning holes to discharge a flowable polymer continuously for forming filaments,

(b) a spinning tube having a filament passage through which the numerous filaments formed by the numerous spinning holes run downward from the spinneret, and installed below and spaced from the spinneret,

(c) an oiling means for applying an oil to the numerous filaments coming out of the spinning tube,

(d) a filament take-up means for taking up the numerous filaments coming from the oiling means, and

(e) a winding means for winding the numerous filaments coming from the filament take-up means,

characterized in that

(f) gas injection holes are provided, which inject gas obliquely downward from outside the numerous filaments entering the filament passage of the spinning tube, toward the numerous filaments, while the numerous filaments are still flowable, to ensure that the numerous filaments can be disposed along one straight line or one circle without overlapping each other, and further to ensure that, subsequently after disposing the numerous filaments, the injected gas can form a gas stream flowing downward together with the numerous filaments in the filament passage of the spinning tube, and

(g) the velocity of the gas stream flowing downward together with the numerous filaments in the filament passage of the spinning tube is not less than 60% of the take-up speed of the numerous filaments taken up by the filament take-up means.

In the yarn production method of the invention, either of the following requirements (g) can be employed instead of the above-mentioned requirement (g).

A method for producing a yarn, wherein

(g) the following relation is satisfied:

$La \leq Lg/2$

where Lg is the distance between the spinneret and the position at which the numerous filaments are solidified to lose their flowability and reach the take-up speed of the numerous filaments taken up by the filament take-up means, and La is the distance between the spinneret and the position at which the acceleration of the numerous filaments becomes largest.

A method for producing a yarn, wherein

(g) a gas suction device is installed between the spinneret and the spinning tube, to suck the gas existing around the numerous filaments and to discharge the gas outside.

In the yarn production method of the invention, it is preferred that the numerous filaments are disposed along one straight line, that the cross sectional form of the filament passage of the spinning tube is rectangular, that the direction of the long sides of the rectangle agrees with the direction of the straight line, and that the following relation is satisfied:

$d \times 3 \leq Ex \leq d \times 20$

where Ex is the length of the short sides of the rectangle, and d is the diameter of the spinning holes.

In the yarn production method of the invention, it is preferred that the numerous spinning holes are arranged in straight lines, and that the number of the straight lines is 3 or less.

In the yarn production method of the invention, it is preferred that the following relation is satisfied:

$La \leq Lg/2$

where Lg is the distance between the spinneret and the position at which the numerous filaments are solidified to lose their flowability and reach the take-up speed of the numerous filaments taken up by the filament take-up means, and La is the distance between the spinneret and the position at which the acceleration of the numerous filaments becomes largest.

In the yarn production method of the invention, it is preferred that a velocity of the gas stream flowing downward together with the numerous filaments in the filament passage of the spinning tube is higher than the running speed of the numerous filaments in the range of the distance Lg between the spinneret and the position at which the running speed of the numerous filaments reaches the take-up speed of the numerous filaments taken up by the filament take-up means.

In the yarn production method of the invention, it is preferred that a gas suction and discharge means for sucking and discharging gas existing around the numerous filaments running from the spinning holes toward the filament passage is installed between the spinneret and the spinning tube, to ensure that the gas existing around the numerous filaments can be sucked and discharged.

In the yarn production method of the invention, it is preferred that the numerous filaments are disposed along one straight line, that the cross sectional form of the filament passage of the spinning tube is rectangular, that the direction of the long sides of the rectangle agrees with the direction of the straight

line, and that the following relation is satisfied

$$Ex \leq 10 \text{ mm}$$

where Ex is the length of the short sides of the rectangle.

The apparatus for producing a yarn of the invention is as follows.

An apparatus for producing a yarn consisting of numerous filaments, having:

(a) a spinneret having numerous spinning holes formed to discharge a flowable polymer continuously for forming filaments,

(b) a spinning tube having a filament passage through which the numerous filaments formed by the numerous spinning holes run downward from the spinneret, and installed below and spaced from the spinneret,

(c) an oiling means for applying an oil to the numerous filaments coming out of the spinning tube,

(d) a filament take-up means for taking up the numerous filaments coming from the oiling means, and

(e) a winding means for winding the numerous filaments coming from the filament take-up means,

characterized in that

(f) gas injection holes are provided, which inject gas obliquely downward from outside the numerous filaments entering the filament passage of the spinning tube, toward the numerous filaments, while the numerous filaments are still flowable, to ensure that the numerous filaments can be disposed along one straight line or one circle without overlapping each other, and

further to ensure that, subsequently after disposing the numerous filaments, the injected gas can form an air stream flowing downward together with the numerous filaments in the filament passage of the spinning tube, and

(g) a means is provided for adjusting the injection conditions of the gas injected from the gas injection holes or adjusting the take-up speed of the numerous filaments taken up by the filament take-up means, to ensure that the velocity of the gas stream flowing downward together with the numerous filaments in the filament passage of the spinning tube is not less than 60% of the take-up speed of the numerous filaments taken up by the filament take-up means.

In the yarn production apparatus of the invention, either of the following requirements (g) can be employed instead of the above-mentioned requirement (g).

An apparatus for producing a yarn, wherein

(g) the following relation is satisfied:

$La \leq Lg/2$

where Lg is the distance between the spinneret and the position at which the numerous filaments are solidified to lose their flowability and reach the take-up speed of the numerous filaments taken up by the filament take-up means, and La is the distance between the spinneret and the position at which the acceleration of the numerous filaments becomes largest.

An apparatus for producing a yarn, wherein

(g) a gas suction device is installed between the spinneret

and the spinning tube, to suck the gas existing around the numerous filaments and to discharge the gas outside.

In the yarn production apparatus of the invention, it is preferred that the numerous filaments are disposed along one straight line, that the cross sectional form of the filament passage of the spinning tube is rectangular, that the direction of the long sides of the rectangle agrees with the direction of the straight line, and that the following relation is satisfied:

$$d \times 3 \leq Ex \leq d \times 20$$

where Ex is the length of the short sides of the rectangle, and d is the diameter of the spinning holes.

In the yarn production apparatus of the invention, it is preferred that the numerous spinning holes are arranged in straight lines, and that the number of the straight lines is 3 or less.

In the yarn production apparatus of the invention, it is preferred that the following relation is satisfied:

$$La \leq Lg/2$$

where Lg is the distance between the spinneret and the position at which the numerous filaments are solidified to lose their flowability and reach the take-up speed of the numerous filaments taken up by the filament take-up means, and La is the distance between the spinneret and the position at which the acceleration of the numerous filaments becomes largest.

In the yarn production apparatus of the invention, it is preferred that the velocity of the gas stream flowing downward together with the numerous filaments in the filament passage of

the spinning tube is higher than the running speed of the numerous filaments in the range of the distance Lg between the spinneret and the position at which the running speed of the numerous filaments reaches the take-up speed of the numerous filaments taken up by the filament take-up means.

In the yarn production apparatus of the invention, it is preferred that a gas suction and discharge means for sucking and discharging gas existing around the numerous filaments running from the spinning holes toward the filament passage is installed between the spinneret and the spinning tube, to ensure that the gas existing around the numerous filaments can be sucked and discharged.

In the yarn production apparatus of the invention, it is preferred that the numerous filaments are disposed along one straight line, that the cross sectional form of the filament passage of the spinning tube is rectangular, that the direction of the long sides of the rectangle agrees with the direction of the straight line, and that the following relation is satisfied:

$$Ex \leq 10 \text{ mm}$$

where Ex is the length of the short sides of the rectangle.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic typical view showing a conventional yarn production apparatus.

Fig. 2 is a schematic typical view showing the bottom face of the spinneret used in the apparatus of Fig. 1.

Fig. 3 is a schematic typical view showing another conventional yarn production apparatus than the apparatus of Fig. 1.

Fig. 4 is a schematic typical view showing an embodiment of the yarn production apparatus of the invention.

Figs. 5A, 5B and 5D are schematic typical views showing the bottom faces of three typical examples of the spinneret used in the apparatus of Fig. 4. Fig. 5C is a projected typical front view showing the spinneret of Fig. 5B. Fig. 5E is a projected typical front view of the spinneret of Fig. 5D.

Fig. 6 is a schematic vertical sectional view showing the spinning tube used in the apparatus of Fig. 4.

Fig. 7 is a schematic X-X cross-sectional view showing the spinning tube of Fig. 6.

Fig. 8 is a schematic perspective view showing a partial upper portion of the spinning tube of Fig. 4.

Fig. 9 is a schematic vertical sectional view showing another mode of the spinning tube of Fig. 4.

Fig. 10 is a schematic vertical sectional view showing a lower portion of a further other mode of the spinning tube of Fig. 4.

Fig. 11 is a partial schematic vertical sectional view showing a mode in which a discharge-destined flow suction means is provided below the spinning tube in the apparatus of Fig. 4.

Fig. 12 is a partial schematic vertical sectional view showing a mode in which flow regulation sections are installed

above the spinning tube in the apparatus of Fig. 4.

Fig. 13 is a perspective view showing an example of the grate members installed in the flow regulation sections of Fig. 12.

Fig. 14 is a partial schematic perspective view showing a mode in which an air stream regulation means is installed above the spinning tube in the apparatus of Fig. 4.

Fig. 15 is a schematic perspective view showing a temperature regulation means installed above the spinning tube in the apparatus of Fig. 4.

Fig. 16 is a schematic perspective view showing another mode of the temperature regulation means of Fig. 15.

Fig. 17 is a partial schematic vertical sectional view showing a mode in which a compressed air circulation passage is added to the spinning tube in the apparatus of Fig. 4.

Fig. 18 is a schematic typical view showing another embodiment of the yarn production apparatus of the invention.

Fig. 19 is a schematic vertical sectional view showing a mode of the gas suction device used in the apparatus of Fig. 18.

Fig. 20 is a schematic vertical sectional view showing another mode of the gas suction device used in the apparatus of Fig. 18.

Fig. 21 is a schematic vertical sectional view showing a further other mode of the gas suction device used in the apparatus of Fig. 18.

Fig. 22 is a schematic cross sectional view showing the gas suction device used in the apparatus of Fig. 18.

Fig. 23 is a schematic typical view showing a further other embodiment of the yarn production apparatus of the invention.

Fig. 24 is a schematic perspective view showing a mode of the grate members of the flow regulation sections of Fig. 23.

Fig. 25 is a schematic perspective view showing the flow regulation sections of Fig. 23.

Fig. 26 is a schematic typical view showing a further other embodiment of the yarn production apparatus of the invention.

Fig. 27 is a graph showing how the speed of the filaments composed of a polymer discharged from the spinneret changes in relation with the distance from the spinneret in the apparatus of Fig. 4.

Fig. 28 is a schematic perspective view showing the spinning tube and the oiling means installed in the apparatus of Fig. 4.

Fig. 29 is a schematic perspective typical view showing a further other embodiment of the yarn production apparatus of the invention.

Fig. 30 is a partial schematic perspective typical view showing a further other embodiment of the yarn production apparatus of the invention.

Fig. 31 is a partial schematic perspective typical view showing a further other embodiment of the yarn production apparatus of the invention.

Fig. 32 is a schematic typical view for illustrating the method of measuring the running speed of filaments.

Fig. 33 is a graph showing how the speed of the filaments

composed of a polymer discharged from the spinneret changed in relation with the distance from the spinneret in Examples 1 through 4.

Fig. 34 is a graph showing how the speed of the filaments composed of a polymer discharged from the spinneret changed in relation with the distance from the spinneret in Comparative Examples 1 through 3.

Fig. 35 is a graph showing how the speed of the filaments composed of a polymer discharged from the spinneret changed in relation with the distance from the spinneret in Examples 1 and 5 and Comparative Example 4.

THE BEST MODES FOR CARRYING OUT THE INVENTION

Embodiments of the invention are described below further in reference to drawings.

In the following embodiments, the method and apparatus for producing a polyester yarn, especially a partially oriented yarn (POY) are described.

In Fig. 4, a yarn production apparatus 10 of the invention has a spinneret 12 engaged with a spinning block 11 in a melt-spinning machine (not illustrated) and having numerous spinning holes 13 formed for continuously discharging a flowable polymer for forming filaments. Below the spinneret 12 and being spaced from the spinneret 12, a spinning tube (ejector) (air applying means) 20 is installed. The spinning tube 20 has a filament passage 25 (Fig. 6) through which the numerous filaments F formed by the numerous

spinning holes 13 and running downward from the spinneret 12 pass. Downstream of the spinning tube 20, an oiling means 17 is installed for applying an oiling agent to the numerous filaments F coming from the filament passage 25 of the spinning tube 20. Further, a first godet roller 14 and a second godet roller 15 constituting a filament take-up means are installed for taking up the numerous filaments F coming from the oiling means 17. Still further, a winding means 16 is installed for winding the numerous filaments F coming from the filament take-up means. The numerous filaments F are wound around a bobbin 16a as a yarn Y by the winding means 16, to form a yarn package 16b.

The spinning tube 20 can be moved vertically by means of an elevator 26 installed outside. The elevator 26 comprises a vertically extending and rotatable column 26d provided with a ball screw 26b, a motor 26c for rotating the column 26d, and a spinning tube support arm 26a connected at one end with the ball screw 26b, to be able to move vertically along the column 26d with the rotation of the ball screw 26b, and connected at the other end with the spinning tube 20. The elevator 26 is actuated to adjust the distance between the bottom face of the spinneret 12 and the top face of the spinning tube 20 to a desired value.

Fig. 5A is a bottom face view showing an example of the spinneret 12 used in the apparatus of Fig. 4. The spinneret 12A of Fig. 5A has numerous spinning holes 13 having a hole diameter of d (mm). The numerous spinning holes 13 are arranged along a straight line Z at a pitch of P (mm). Six spinning holes 13 are

shown in Fig. 5A. In the drawing, the distance between the center of the rightmost spinning hole 13 and the center of the leftmost spinning hole 13 is indicated by symbol dw.

Fig. 5B is a bottom face view showing another example of the spinneret 12 used in the apparatus of Fig. 4. The spinneret 12B of Fig. 5B has the spinning holes 13 of the spinneret 12A of Fig. 5A in two rows, instead of one row. The spinnerets 13 are arranged along straight lines Z1 and Z2 parallel to each other. The positions of the spinning holes 13 on the straight line Z1 and the positions of the spinning holes 13 on the straight line Z2 are shifted from each other in the straight-line direction. This state is shown in Fig. 5C as projected on the plane including the straight-line direction and the direction of the vertical line to the spinneret 12B. This state is necessary to ensure that the numerous filaments F are disposed along one straight line without overlapping each other in the case where air is injected obliquely downward from outside the numerous filaments F toward the numerous filaments in the spinning tube 20 described later. In Fig. 5B, the centers of the respective spinning holes 13 are positioned on the straight lines Z1 and Z2 respectively, and the distance between the arrangement of the spinning holes 13 on the straight line Z1 and the arrangement of the spinning holes 13 on the straight line Z2 is the distance in the direction perpendicular to the straight lines Z1 and Z2, and this distance is indicated by symbol W in Fig. 5B. This distance W is the longest distance between the arrangement lines of spinnerets, that is, in the case where

the spinning holes are arranged in 3 rows, the outermost two straight lines are selected for referring to the distance W.

Fig. 5D is a bottom face view showing a further other example of the spinneret 12 used in the apparatus of Fig. 4. In the spinneret 12D of Fig. 5D, the spinning holes 13 are not arranged regularly like straight lines on the surface of the spinneret. The spinning holes 13 are arranged at random. This state is shown in Fig. 5E as projected on the plane including the straight-line direction and the direction of the vertical line to the spinneret 12D. This state is necessary to ensure that the numerous filaments F are disposed along one straight line without overlapping each other in the case where air is injected obliquely downward from outside the numerous filaments F toward the numerous filaments in the spinning tube 20 described later. In Fig. 5D, the distance between the centers of the spinning holes 13 of the outermost positions in the width direction (the direction perpendicular to the longitudinal direction) of the spinneret 12D is indicated by symbol W. In this case, it is preferred that the following relation is satisfied.

$$W \leq 10Ex$$

where Ex is the length of the short sides 21S of the rectangle as the cross sectional form of the filament passage 25 of the spinning tube 20 described later.

As for the arrangement of the numerous spinning holes 13 in the spinneret 12, they can also be arranged like a circle, though such an arrangement is not illustrated in the drawings Figs. 5A-5E.

In the case where the same number of spinning holes are arranged in the spinneret, if the spinning holes are arranged in plural rows, the length of the spinning tube 20 in the straight-line Z direction can be shortened, and the flow rate Ef of the air injected into the spinning tube 20 can be decreased, to allow the reduction of operation cost. If the distance W between the respective rows is too large, the discharged filaments F composed of a polymer may be bent greatly, to make the produced yarn irregular. It is preferred to keep the distance W between the respective rows as small as possible, considering the phenomenon that the filaments F are swollen at a position immediately below the spinning holes 13.

The structure of the spinning tube 20 used in the apparatus of Fig. 4 is explained below in reference to Fig. 6.

The spinning tube 20 comprises an air inlet section 22, an air injection section 23, a steady flow section 21 and an air discharge section 24 in this order from the upstream side toward the downstream side. The spinning tube 20 has a filament passage 25 through which the numerous filaments F discharged from the spinning holes 13 of the spinneret 12 run toward the filament take-up means 14, in the range from the air inlet section 22 to the air discharge section 24.

The air injection section 23 has air injection holes 23a in the wall faces of the filament passage 25 on both sides for injecting air obliquely downward from outside the running numerous filaments F toward the numerous filaments F. The air injection

holes 23a are connected with an air supply device 41, and compressed air 41a is supplied to the air injection holes 23a. The supplied compressed air 41a is injected into the filament passage 25 from the air injection holes 23a. The injection causes outside air to be sucked from the top opening of the spinning tube 20 into the air inlet section 22 in the filament passage 25, to form a suction air flow. The sucked air and the air injected from the air injection holes 23a flow toward the downstream side in the filament passage 25 and become an air stream with a constant velocity in the steady flow section 21. The air stream that has passed through the steady flow section 21 is discharged outside from the air discharge section 24. The air flow injected from the air injection holes 23a causes the numerous filaments F entering the filament passage 25 to be disposed in a straight line without overlapping each other in the direction perpendicular to the paper surface in Fig. 6, and the filaments as disposed like this run toward the oiling means 17.

The X-X sectional view of the spinning tube 20 shown in Fig. 6 is shown in Fig. 7. In Fig. 7, the cross sectional form of the filament passage 25 is rectangular. The rectangular form is kept in the range from the inlet of the filament passage 25 in the air inlet section 22 to the outlet of the filament passage 25 in the air discharge section 24.

The direction of the long sides 21L of the rectangle agrees with the direction in which the spinning holes 13 of the spinneret 12 are arranged side by side. Therefore, the direction of the

short sides 21S of the rectangle is perpendicular to the direction in which the spinning holes 13 of the spinneret 12 are arranged side by side.

The length Ey of the long sides 21L of the rectangle as the cross sectional form of the filament passage 25 is only required to be larger than the distance dw (mm) between the outermost spinning holes 13 of the spinneret 12A, 12B or 12D shown in Fig. 5A, 5B or 5D. Among the air inlet section 22, the air injection section 23, the steady flow section 21 and the air discharge section 24, the sizes of the respective rectangles may be different, and in this case, it is only required that the smallest length of the long sides 21L, 22L, 23L and 24L of the rectangles is larger than the distance dw between the outermost spinning holes. However, it is preferred that the sizes of the respective rectangles are equal among the air inlet section 22, the air injection section 23, the steady flow section 21 and the air discharge section 24.

On the other hand, in order that the running numerous filaments F can be stably introduced into the filament passage 25, it is more preferred that the following relation is satisfied:

Length Ey of the long sides of the rectangle ≥ (Distance dw between the outermost spinning holes + Pitch P of spinning holes)

Furthermore, in order that the air injected into the filament passage 25 from the air injection holes 23a can act on the numerous filaments F efficiently without waste, it is more preferred the following relation is satisfied:

Length Ey of the long sides of the rectangle ≤

(Distance dw between the outermost spinning holes + Pitch P of spinning holes x 30) .

If the length Ex of the short sides of the rectangle is too small, the filaments are liable to clog the filament passage 25. It is preferred that the respective short sides 21S, 22S, 23S and 24S of the air inlet section 22, the air injection section 23, the steady flow section 21 and the air discharge section 24 satisfy the following relation:

Length Ex of the short sides of the rectangle ≥

(Diameter d of the spinning holes x 3)

Moreover, in the steady flow section 21, if the length Ex of the short side of the rectangle is too large, the running of the numerous filaments F is destabilized. So, it is preferred that the following relation is satisfied.

Length Ex of the short sides of the rectangle ≥

(Diameter d of the spinning holes x 20)

In the apparatus shown in Fig. 6, the air inlet section 22 has a widened portion 22a. If the smallest value 22w (see Fig. 9) of the short sides of the rectangle as the cross sectional form of the filament passage 25 in the air inlet section 22 and the smallest value 21w (see Fig. 9) of the short sides of the rectangle as the cross sectional form of the filament passage 25 in the steady flow section 21 are set to be different from each other, the amount of the air sucked from outside in the air inlet section 22 can be set at a desired value.

In Fig. 6, the air injection section 23 has air injection holes 23a for injecting air for the numerous filaments F running in the filament passage 25, to form an air stream for ensuring that the numerous filaments F are disposed in a straight line without overlapping each other. The air injection holes 23a have an injection angle of θ against the running direction of the numerous filaments F, to ensure that the compressed air 41a flows toward the air discharge section 24. It is preferred that the injection angle θ is 45° or less. If the injection angle θ is more than 45°, the injected air may flow toward the air inlet section 22, to disturb the running of the numerous filaments F.

For enhancing the efficiency of suction of the numerous filaments F into the passage 25 and reducing the size of the spinning tube 20, it is preferred that the injection angle θ be in a range of 5° to 15°. Furthermore, the injection holes 23a are installed on the long sides of the filament passage rectangular in the cross section shown in Fig. 7, but the injection holes 23a can be slits extending in the full length of the long sides 21L of the rectangle or arrangements of plural circular holes 32a as shown as a perspective view in Fig. 8.

As shown in Fig. 9, the spinning tube 20 can also comprises injection blocks 23b, 23c and the like that can be assembled and disassembled. In this constitution, for example, the injection angle θ of the injection holes, the slit width Ei of the injection holes 23a (or the diameter of circular holes), and the smallest values 21w or 22w of the short sides of the rectangle as the cross

sectional form of the filament passage 25 in the air inlet section 22 or the steady flow section 21 can be easily changed to suit desired operation conditions.

The air inlet section 22 has a widened portion 22a on the most upstream side (the inlet of the filament passage 25) as shown in Fig. 6. In this constitution, the sucked flow 42a of outside air formed by the compressed air 41a injected from the injection holes 23a can be smoothly formed into the filament passage 25. The widened portion 22a can be tapered or formed like a rounded trumpet.

The air discharge section 24 has a widened portion 24a on the most downstream side (the outlet of the filament passage 25) as shown in Fig. 6. In this constitution, the compressed air 41a from the air injection section 23 and the sucked flow 42a join to form a running air stream 40, and after it has flowed through the steady flow section 21, it becomes discharge-destined flow 43a at the bottom end of the air discharge section 24, being discharged outward from the filament passage 25. The widened portion 24a can be tapered, but it is preferred that the widened portion is curved, since the discharge-destined flow 43a can be smoothly discharged. Furthermore, as shown in Fig. 9, if the bottom end portion of the widened portion 24a is extended to have a predetermined length 24N having a constant width 24w maintained, an effect of diffusing the discharge-destined flow 43a can be obtained while the discharge-destined flow 43a is kept regulated, to further stabilize the numerous filaments F. On the other hand,

it is also allowed that the air discharge section 24 does not have the widened portion 24a. That is, the wall faces of the steady flow section 21 can extend straight downward. In this constitution, the structure of the spinning tube 20 can be simplified.

In the case where the discharge-destined flow 43a should swing the filaments at or before the oiling means 17 (see Fig. 4) installed downstream of the spinning tube 20, suction ports 46 can be formed in the air discharge section 24 of the spinning tube 20 as shown in Fig. 10, to positively eliminate the discharge-destined flow 43a from the suction ports 46 using a suction blower 45. In this constitution, the discharge-destined flow 43a can be prevented from flowing toward the downstream side of the bottom end of the spinning tube 20.

As shown in Fig. 11, a discharge-destined flow suction means 47 connected with a suction blower 45 can also be installed downstream of the bottom end of the spinning tube 20 and upstream of the oiling means 17, for sucking the discharge-destined flow 43a. In this case, it is preferred that the cross sectional form of the passage of the discharge-destined flow suction means 47 is rectangular like the cross sectional form of the filament passage 25 of the spinning tube 20, and that suction faces 44a are formed on the faces parallel to the direction in which the running numerous filaments F are disposed side by side. It is also allowed that the suction ports 46 are formed in the air discharge section 24 of the spinning tube 20 as shown in Fig. 10, and in addition, that the discharge-destined flow suction means 47 is installed as shown

in Fig. 11.

In order to regulate the sucked flow 42a formed by the spinning tube 20, as shown in Fig. 12, it is preferred to install flow regulation sections 31 having, for example, honeycomb-like grate members. In this constitution, the sucked flow 42a with a predetermined direction can be formed, and a stable air stream can be given to the running numerous filaments F.

The flow regulation sections 31 are only required to be such that the grate members are installed in parallel to the direction in which the running numerous filaments F are disposed side by side, and if the cross sectional form of the passage in the flow regulation sections 31 is rectangular like the filament passage 25 of the spinning tube 20, an air stream can be caused to act more uniformly on the running numerous filaments F. Furthermore, one of the grate members can be installed only on one side of the long sides of the disposed numerous filaments F, but for stabilizing the running of numerous filaments F more positively, it is preferred to install the grate members on both sides of the disposed numerous filaments F.

If each of the grate members comprises two grate components 31x and 31y overlaid on each other as shown in Fig. 13, the size of the formed holes 31z can be adjusted to allow the flow rate of the sucked flow 42a to be easily controlled. Furthermore, for smoothing the sucked flow 42a, it is preferred that the top end of the air inlet section 22 of the spinning tube 20 and the bottom end of the flow regulation sections 31 are joined to be flush with

each other without any difference formed at a joint 29 of Fig. 12, to ensure that the passage in the flow regulation sections 31 and the filament passage 25 of the spinning tube 20 can be connected smoothly.

As shown in Fig. 14, an air stream regulation means 30 having both the function of the flow regulation sections 31 shown in Fig. 12 and the function of regulating the temperature of the supplied air can also be installed upstream of the top end of the spinning tube 20. The air stream regulation means 30 is connected to a temperature-regulated air supply section 33. The air 32a adjusted at a desired temperature supplied from the temperature-regulated air supply section 33 is regulated by the grate members of the flow regulation sections 31, and is positively supplied to the running numerous filaments F. Since air adjusted at a desired temperature is supplied, the numerous filaments F existing before the spinning tube 20 are cooled, insulated or heated, depending on the situation. In this constitution, the temperature of the numerous filaments F can be controlled at a desired temperature.

The air 32a can be supplied from both sides of the running numerous filaments F, but it is preferred that the temperature-regulated air is supplied to the numerous filaments F from one side, while the air used is sucked from the other side. In this constitution, the air stream formed in the spinning tube 20 can be controlled separately from the air stream formed by the air stream regulation means 30. Furthermore, the volatile substance generated from the numerous filaments F can also be sucked

for removal, and the contamination of the spinning tube 20 caused by the volatile substance deposited on the inside of the spinning tube 20 can also be prevented.

On the upstream side of the top end of the spinning tube 20, a temperature regulation means 35 can also be installed as shown in Fig. 15 for controlling the temperature of the numerous filaments F. The temperature regulation means 35 comprises a temperature regulation pipe 37 shaped like a block, a rectangular temperature regulation passage 35a formed inside the temperature regulation pipe 37, and heating members 36 such as ceramic heaters installed in the long side 37a direction to oppose the numerous filaments F running in the temperature regulation passage 35a. The temperature regulation means 35 is equipped with a temperature controller 38a and a thermometer 38, for controlling the temperature of the heating members 36, and as a result, the temperature of the atmosphere in the temperature regulation passage 35a can be controlled. In the case where the temperature regulation means 35 is used, the heating members 36 are installed in the direction in which the numerous filaments F are disposed side by side in such a manner that the faces of the long sides 37a of the temperature control pipe 37 can be flush with the faces of the long sides 21L of the steady flow section 21 of the spinning tube 20. The temperature regulation means 35 can also be cylindrical in appearance as shown in Fig. 16, if the temperature regulation passage 35a of the temperature regulation pipe 37 through which the numerous filaments F pass have a rectangular outlet 39a.

Both the air stream regulation means 30 shown in Fig. 14 and the temperature regulation means 35 shown in Fig. 15 can also be used together to control the temperature of the numerous filaments F existing upstream of the top end of the spinning tube 20.

For the flow regulation sections 31 and the air stream regulation means 30 shown in Fig. 14, and the temperature regulation means 35 shown in Fig. 15, it is preferred that the top end face of the air stream regulation means 30 or the temperature regulation means 35 and the bottom end face of the spinneret 12 or the spinning block 11 are connected with each other to achieve air tightness, for preventing that the outside air flows through the clearance between such a means and the spinneret 12 for disturbing the air stream in the inside filament passage and to prevent that the spinneret 12 is cooled.

As shown in Fig. 17, the air supply device 41 for the spinning tube 20 shown in Fig. 6 and the suction ports 46 formed in the air discharge section 24 shown in Fig. 10 (or the discharge-destined flow suction means 47 shown in Fig. 11) can also be connected with each other, to use the compressed air 41a supplied to the spinning tube 20 in circulation. In this case, before the compressed air 41a is supplied to the spinning tube 20, an air controller 49 for controlling, for example, the temperature and the flow rate should be installed, and the signal of the air controller 49 should be used to adjust the opening of a valve 41y of a supply pipe 41x, for example in the case where the flow rate of the compressed air

41a is insufficient.

As shown in Fig. 17, in the case where the air stream regulation means 30 is installed upstream of the top end of the spinning tube 20, the air recovered from the suction ports 46 of the air discharge section 24 (or the discharge-destined flow suction means 47 shown in Fig. 11) can be fed through a bypass pipe 48 for supply again to the air stream regulation means 30 as supply air 32a.

A mode in which a gas suction device is installed between the spinneret and the spinning tube is described below.

Fig. 18 shows a spinning apparatus, in which a gas suction device 60 is installed immediately below the spinneret 12, and the spinning tube 20 spaced from the bottom end of the gas suction device 60 is installed below the gas suction device 60. In Fig. 19, the gas suction device 60 is installed between the spinneret 12 and the spinning tube 20 detachably from the spinning apparatus. The gas suction device 60 sucks the gas containing the volatile substance generated from the numerous filaments F composed of a polymer discharged from the spinning holes 13 of the spinneret 12.

The gas suction device 60 comprises suction buffers 61 and gas suction ports 62 composed of gas permeable grate members. The gas suction ports 62 are installed on both sides of the row of the numerous filaments F composed of a polymer discharged from the spinneret 12, to face the numerous filaments F in parallel to them. The suction buffers 61 are connected with a gas suction blower 63 for carrying the gas sucked from the gas suction ports

62 to outside the apparatus, through a volatile substance collection filter 64. Thus the gas is sucked from the both sides of the row of the numerous filaments F. In this constitution, swinging of the numerous filaments F due to the suction can be reduced. The volatile substance collection filter 64 removes the volatile substance contained in the sucked gas, and the remaining gas is discharged from the gas suction blower 63 to the atmosphere.

If the gas suction device 60 is positioned with its top face kept as close to the bottom face of the spinneret 12 as possible, the gas can be effectively sucked. However, if the top face of the gas suction device 60 contacts the bottom face of the spinneret 12, the gas suction device can cool the spinneret 12. So, it is preferred that the clearance between the bottom face of the spinneret 12 and the top face of the gas suction device 60 (the distance between both in the vertical direction) expressed by SL satisfies a relation of $SL \geq 2$ mm.

The gas suction ports 62 are formed in planes parallel to the row of the numerous filaments F. If the gas suction ports 62 are closer to the row of the numerous filaments F, the gas suction efficiency is higher. However, if they are too close, the gas flow caused by suction causes the numerous filaments F to be swung greatly, and it may happen that the numerous filaments F are fused to each other. If the suction distance from the gas suction ports 62 to the row of the numerous filaments F is PL, it is preferred to satisfy a relation of 2 mm $\leq PL \leq$ 20 mm.

It is desirable to use flow regulation members low in gas

flow resistance such as honeycomb members as the gas suction ports 62 for regulating the flow of sucked gas.

The amounts of sucked gas can be adjusted to desired flow rates by means of the suction adjusting valves 65. It is desirable to use flow meters 66 provided for measuring both the flow rates, to equalize the flow rates of the gas sucked by both the suction ports 62. In this constitution, the numerous filaments F can be prevented from swinging. The flow rate can be controlled easily based on the correlation between the values indicated by a negative pressure gauge 67 and the gas velocities measured beforehand at the gas suction port 62.

Since the running speed of the numerous filaments F running immediately below the spinneret 12 is small, the moving velocity of the gas generated from the numerous filaments F running immediately below the spinneret 12 is also small. So, the gas suction velocity can be very small. Though depending on the distance between the gas suction ports 62 and the numerous filaments F, it is preferred that the gas suction velocity is in a range of 5 m/min to 30 m/min. Since the running speed of the numerous filaments F on the more downstream side is higher, it is desirable to adjust the gas suction ports 62 for ensuring that the suction flow rates on the downstream side become higher than those on the upstream side in the gas suction device 60. In this constitution, the gas accompanying the running numerous filaments F can be efficiently collected.

If the gas suction device 60 sucks the gas existing around

the numerous filaments F, there occurs a phenomenon that the outside air is sucked from the surrounding. In this phenomenon, the incoming outside air lowers the temperature around the spinneret 12, and as a result, the spinnability may be impaired.

To prevent this phenomenon, it is desirable to install a heat insulating plate 12L below the bottom face of the spinneret 12 as shown in Fig. 20.

As another means, it is desirable to keep the suction buffers 61 of the gas suction device 60 spaced from the spinneret 12 as shown in Fig. 21. This can be achieved if the top faces of the suction buffers 61 are kept in contact with the bottom face of the spinning block 11 directly or indirectly through a packing 11p. As a further other means, for example, the clearance between the bottom face of the spinning block 11 and the top faces of the suction buffers 61 can be perfectly closed by means of the packing 11p. In this constitution, the space between the bottom face of the spinneret 12 and the top face of the gas suction device 60 is kept gas-tight.

Fig. 22 is a sectional view of the suction device 60 in the direction perpendicular to the direction vertical to the bottom face of the spinneret 12 (the direction perpendicular to the running direction of the numerous filaments F in the case where the numerous spinning holes 13 of the spinneret 12 are arranged on one straight line).

In the case where the gas suction device 60 sucks the outside air from both the lateral sides 62a open to the outside air of

the gas suction ports 62, it can happen that the gas suction device 60 sucks the gas positioned around the filaments F running on both lateral sides of the numerous filaments F more strongly than the gas positioned around the filaments F running inside among the numerous filaments F. In this case, the produced numerous filaments constituting a yarn become different from each other (irregular) in properties. To avoid this phenomenon, it is desirable to close both the lateral sides open to the outside air of the gas suction ports 62 using side plates 68.

For the outside air flowing in from the bottom openings of the gas suction device 60, it is desirable to install flow regulation sections 31 each having a honeycomb grate member 88 as shown in Fig. 24, between the bottom face of the gas suction device 60 and the top face of the spinning tube 20, for regulating the inflow direction.

In Fig. 23, the outside air 81a incoming from suction spaces 80 forms an ascending stream against the running direction of the numerous filaments F. Because of the ascending stream, the gas otherwise destined to flow down accompanying the running numerous filaments F is turned toward the gas suction device 60, and collected by the gas suction device 60. As a result, the inflow of the gas generated near the spinneret 12 into the spinning tube 20 installed downstream of the gas suction device can be prevented.

If the flow regulation sections 31 each having the suction space 80 is installed between the bottom end of the gas suction device 60 and the top end of the spinning tube 20, the sucked flow

42a caused by the spinning tube 20 is also regulated in the downstream portion in the flow regulation sections 31. In this constitution, the sucked flow 42a directed as desired is allowed to flow into the filament passage 25 of the spinning tube 20. Thus, a stable air stream with a small volatile matter content flows into the filament passage 25 of the spinning tube 20.

It is preferred that the flow regulation sections 31 are provided with grate members 88 arranged with their longitudinal direction kept in parallel with the direction in which the running numerous filaments F are disposed side by side. The cross sectional form of the filament passage in the flow regulation sections 31 can be rectangular like the cross sectional form of the filament passage 25 in the spinning tube 20. In this constitution, the air stream can be caused to more uniformly act on the running numerous filaments F.

It is preferred that the suction spaces 80 of the flow regulation sections 31 are provided on both sides of the disposal of the numerous filaments F, to further stabilize the running of the numerous filaments F.

It is only required that the grate members 88 installed in the flow regulation sections 31 are installed to ensure that the air streams are regulated in the direction perpendicular to the direction in which the numerous filaments F are disposed side by side, in planes perpendicular or inclined to the disposal faces of the numerous filaments F (for example, the disposal faces of the numerous filaments F formed by the row of spinning holes

indicated by the straight line Z in Fig. 5A). The inclination angle can also change from the top ends to the bottom ends of the grate members 88.

Fig. 24 is a perspective view showing either of the grate members 88 used in the flow regulation sections 31 and also the thickness 88t of the grate member 88 in the flow regulation direction. If the thickness 88t in the flow regulation direction is larger, the flow regulation effect is higher. It is preferred that the grate member 88 is formed to have a thickness 88t of 5 mm or more.

The flow regulation sections 31 can also be connected with a blower 33 as shown in Fig. 25. The blower 33 positively supplies air to the flow regulation sections 31 of the suction spaces 80, to assist the flow of the outside air 81a flowing toward the suction device 60 and the flow of the sucked flow 42a flowing toward the spinning tube 20. Depending on the kind, condition or the like of the polymer constituting the running filaments, an inert gas such as nitrogen can also be introduced. Hot air or cold air can also be introduced to control the temperature of the air acting on the numerous filaments F.

In the production of a yarn, it can happen that a filament is broken. An example of how to deal with the situation is described below in reference to Fig. 26. In Fig. 26, in order to monitor the running passage of the yarn Y, a filament break sensor 96 is installed between the second godet roller 15 and the winding means 16. When a filament is broken, the filament break sensor 96 detects it and issues a filament break detection signal. On the other

hand, a sucker 95 is installed between the spinning tube 20 and the oiling means 17, to face the running passage of the yarn Y consisting of numerous filaments F. The sucker 95 is connected with a waste yarn blower 94. If the waste yarn blower 94 is actuated based on a filament break detection signal, the sucker 95 sucks the yarn Y.

Even if a filament is broken, the numerous filaments F continuously formed by the spinning holes 13 of the spinneret 12 keep running on the upstream side of the position where the breaking has occurred. The numerous filaments F continuously running from the spinneret 12 are sucked and taken up by the waste yarn blower 94 and the sucker 95 respectively actuated based the filament break detection signal issued by the filament break sensor 96 when the sensor has detected the breaking. Then, the yarn taken up by the sucker 95 is discharged from the sucker 95 and accommodated in a waste yarn container 97. In this constitution, the winding of the yarn around the first godet roller 14 and the second godet roller 15 is prevented. It is preferred that the sucker 95 is installed in such a manner that it opens toward the air discharge section 24 of the spinning tube 20 and can move horizontally in the direction in which the numerous filaments F are disposed side by side (the long side direction of the filament passage 25 of the spinning tube 20).

Next, the yarn production method of the invention is described below in reference to Figs. 4 and 6.

The air supply device 41 injects the compressed air 41a

obliquely downward into the filament passage 25 of the spinning tube 20 from the injection holes 23a. As a result, the air stream 40 running downward in the filament passage 25 is formed. The spinning tube 20 is installed below the spinneret 12 in the vertical direction in such a manner that the numerous filaments F composed of a polymer discharged as a row(s) from the numerous spinning holes 13 of the spinneret run straight downward in the vertical direction through the filament passage 25 of the spinning tube 20.

With this arrangement, when the running numerous filaments F have arrived at the inlet of the filament passage 25, the sucked flow 42a formed in the air inflow section 22 allows the filaments F to be easily introduced into the filament passage 25, and further allows the filaments F to easily pass through the filament passage 25. If the elevator 26 is actuated to lower the spinning tube 20, the filaments F run stably and can easily pass through the filament passage 25.

A flowable polymer is discharged from the numerous spinning holes 13 arranged in a row(s) in the spinneret 12 provided in the spinning block 11. The discharged polymer forms numerous filaments F disposed in accordance with the arranged spinning holes 13. The formed numerous filaments F are introduced into the inlet of the filament passage 25, and are discharged from the outlet of the filament passage 25. The polymer constituting the numerous filaments F loses its flowability and is solidified while it passes through the filament passage 25 of the spinning tube 20.

Subsequently, while being sucked by a suction gun (not illustrated), the filaments F discharged from the filament passage 25 are fed along the oiling means 17, the first godet roller 14 and the second godet roller 15 sequentially, finally being wound by the winder 16. Thus, the initial work in the production of yarn Y is completed. In the case where the spinning tube 20 used has the suction ports 46 shown in Fig. 10, the operation of the suction blower 45 connected with the suction ports 46 is suspended till the yarn installation work up to the winder 16 is completed, and after the yarn installation work has been completed, the suction blower 45 is actuated.

Thereafter, the polymer is continuously discharged from the spinning holes 13 of the spinneret 12, to form numerous filaments F. From the injection holes 23a formed in the spinning tube 20 toward the filament passage 25, air streams are injected obliquely downward toward the formed numerous filaments F on both sides of the numerous filaments F. Receiving the air streams, the numerous filaments F are disposed in one row without overlapping each other.

Subsequently, the disposed numerous filaments F run downward in the filament passage 25 with the disposal maintained. On the other hand, the air streams injected from the injection holes 23a obliquely downward into the filament passage 25 for contribution to the maintenance of the disposal of the numerous filaments F form a downward running air stream 40 in the filament passage 25. In the filament passage 25, the downward running numerous filaments F and the downward running air stream 40 coexist. The coexistence of the running numerous filaments F and the running air stream

40 in the filament passage 25 allows that the numerous filaments F composed of a polymer discharged from the spinning holes 13 are stably drawn and made thinner. As a result, a high elongation yarn Y having little irregularity among the filaments can be produced at a high speed.

According to the yarn production process, the numerous filaments F composed of a polymer discharged from the spinning holes 13, not yet solidified, are introduced into the filament passage 25 of the spinning tube 20, and are drawn and made thinner there. Therefore, unlike a nonwoven fabric obtained by cooling and solidifying the numerous filaments composed of a polymer discharged from the spinning holes and drawing them with an air stream, a high elongation yarn having little irregularity among the filaments can be produced.

In this yarn production process, since the injection velocity Vs of the compressed air 41a from the injection holes 23 is set at a value higher than the take-up speed Vw of the yarn Y by the first godet roller 14, the velocity of the air running together with the numerous filaments F is kept at higher than the running speed of the numerous filaments F at least in part of the filament passage 25 of the spinning tube 20. In this state, the drawing force by the air stream flowing downward in the filament passage 25 acts on the numerous filaments F.

In this yarn production process, to generate a more preferred drawing force, it is preferred that the running velocity Ve of the running air stream 40 flowing in the steady flow section 21

is kept at not less than a velocity of 60% of the yarn take-up speed Vw.

In the case where the running velocity Ve of the running air stream 40 is too high, the running state of the yarn Y near the oiling means 17 positioned below the spinning tube 20 may be adversely affected. One of the unwanted effects is filament breaking. To prevent such an accident, it is preferred that the running velocity Ve of the running air stream 40 is not more than a velocity of 120% of the yarn take-up speed Vw.

The speed Vf of the filaments F composed of a polymer discharged at an initial speed of Vo from the spinning holes 13 becomes gradually higher with the increase of distance from the spinneret 12 in the vertical direction, and it reaches the yarn take-up speed Vw at a certain point.

This relation is shown in Fig. 27. In the graph of Fig. 27, the distance from the bottom face of the spinneret 12 in the vertical direction is chosen as the abscissa, and the speed of the filaments F at each distance from the bottom face of the spinneret 12 in the vertical direction is chosen as the ordinate. The speed of the filaments F changes as shown by curve A in the graph of Fig. 27. In this case, if the distance from the bottom face of the spinneret 12 to the point where the speed of the filaments F reaches the yarn take-up speed Vw is Lg, and the distance from the bottom face of the spinneret 12 to the point where the gradient of the curve A becomes largest, i.e., the point where the acceleration of filaments F becomes largest, is La, then it is

preferred that a relation of La ≤ Lg/2 is satisfied. This relation can be realized if the position of the spinning tube 20 to the spinneret 12, the polymer discharge condition from the spinneret 13, the condition of running air stream 40 and the yarn take-up condition are adjusted. In the case where the relation of La ≤ Lg/2 is satisfied, the filaments F can be made thinner in the upstream region in the filament passage 25. This constitution facilitates the production of a non-oriented yarn Y, i.e., a high elongation yarn Y.

In the case where the flow regulation sections 31 are installed upstream of the spinning tube 20 as shown in Fig. 12, the outside air flowing from outside into the air inlet section 22 is regulated in flow. In this constitution, regulated sucked flow 42a is formed, and in this state, the sucked flow 42a can be given to the numerous filaments F running as a row in the direction to cross them. This state exhibits an effect of uniformly cooling the numerous filaments F. Thus, a yarn Y having little yarn irregularity can be easily produced.

In the case where the air stream regulation means 30 is installed upstream of the spinning tube 20 as shown in Fig. 14, the atmosphere temperature upstream of the spinning tube 20 can be positively controlled. As shown in Fig. 15, in the case where the temperature regulation means 35 contained in the temperature regulation pipe 37 is installed upstream of the spinning tube 20, the atmosphere in the temperature regulation passage 35a through which the numerous filaments F run can be controlled by radiation

heat. This allows the temperature of the numerous filaments F entering the spinning tube 20 to be controlled at a desired temperature. This temperature control facilitates the production of a yarn Y having desired physical properties.

It is preferred that the temperature of the filaments F entering the filament passage 25 of the spinning tube 20 is 160°C or higher. A more preferred temperature is 200°C or higher. If the temperature of the filaments F is controlled to such a temperature, the injection flow rate Ef of the air injected into the filament passage 25 from the air supply device 41 can be decreased to lower the production cost of the yarn Y.

In the case where a filament is broken while the yarn Y is produced, the filament break sensor 96 detects the filament breaking as shown in Fig. 26, and the drive of the drive system ranging from the first godet roller 14 to the winder 16 is stopped. At the same time, the waste yarn blower 94 is actuated, and the waste yarn sucker 95 sucks the filaments coming from the filament passage 25 as waste filaments F1 while being reciprocated in the direction in which the numerous filaments F are disposed side by side (horizontal direction). It is preferred that while the filament breaking situation is dealt with like this, the injection flow rate Ef of the compressed air 41a into the spinning tube 20 is decreased more or less compared with the normal flow rate.

As shown in Fig. 29, in the case where there are plural yarn production lines, if the respective rotation axes J1, J2 and J3 of the first godet rollers 14, the second godet rollers 15 and

the winding means 16 are kept in parallel with the direction in which the spinnerets 12 and the spinning tubes 20 are arranged side by side, it can be prevented that the yarns Y introduced along the first godet rollers 14 are twisted. This allows the yarns Y to be stably taken up.

When the numerous filaments F are oiled, the numerous filaments F can be bundled as one yarn, but instead, as shown in Fig. 28, an oiling means consisting of a long oil supply roller 17a and an oil coating member 17b for applying an oil to the oil supply roller 17a can also be used for applying an oil to each of the filaments.

As shown in Fig. 30, the spinneret installed in the spinning block 11 can also have plural spinning hole groups 13a, each consisting of plural spinning holes 13, arranged in one direction. As shown in Fig. 31, instead of using one spinneret to be installed in the spinning block 11, plural spinnerets 12 arranged in one direction, each having plural spinning holes 13 arranged in the same one direction, can also be used.

In this case, the plural yarns YY can pass through one spinning tube 20, and further along the roller 17a of one oiling means.

In this case, in the relation between the passage width Eyy in the longitudinal direction, of the filament passage 25 of this spinning tube 20 and the passage width Ey for one spinneret 12 described before (for one yarn), Eyy corresponds to (Ey) x (number of yarns).

According to the yarn production method of the invention,

the properties of the yarn obtained at a production speed of 3,000 m/min or 4,000 m/min by a conventional method can be realized even at a speed of 5,000 m/min or more. The production speed can also be 6,000 min/min to 10,000 m/min even in the case where it is intended to obtain a yarn with similar properties.

Even in a process in which the yarn Y is heated by the first godet roller 14 and drawn between the first godet roller 14 and the second godet roller 15 with the speed of the second godet roller 15 kept higher than the speed of the first godet roller, a similar effect can be obtained.

The yarn production method of the invention satisfies both the quality and productivity of the obtained yarn in good balance, compared with the yarn production methods of the prior art. Therefore, the yarn production method of the invention can also be used, for example, for producing a very thin yarn with a filament fineness of 0.5 dtex or less difficult in the control of yarn quality, and also for producing a monofilament.

Another embodiment of the yarn production method of the invention is described below in reference to Figs. 6, 18 and 19.

The gas suction blower 63 is operated to produce a state in which the gas suction device 60 can suck the gas in the filament passage in the gas suction device 60. On the other hand, the air supply device 41 is operated to inject the compressed air 41a into the filament passage 25 of the spinning tube 20 from the two injection holes 23a opened to face each other in the filament passage 25, and the air streams injected from both the injection holes 23a

collide with each other in the filament passage 25, to form a air stream 40 running downward in the filament passage 25.

The spinning tube 20 is positioned below the spinneret 12 in the vertical direction, to ensure that the numerous filaments F composed of a polymer discharged as a row from the spinning holes 13 of the spinneret 12 can run straight downward in the vertical direction, to pass through the filament passage 25 of the spinning tube 20.

With this arrangement, when the running numerous filaments F reach the inlet of the filament passage 25, the sucked flow 42a formed in the air inlet section 22 allows the filaments F to be easily introduced into the filament passage 25, and facilitates further passage of the filaments F through the filament passage 25. If the elevator 26 is actuated to move the spinning tube 20 further downward from the spinneret 12, the filaments F are progressively cooled and solidified, to facilitate their passage through the filament passage 25, and at the same time, the gas near the spinneret 12 generated from the filaments F is sucked into the filament passage 25 of the spinning tube 20 and discharged outside in the time zone before start of normal operation (before yarn threading). So, the contamination in the spinning tube 20 by the gas containing the volatile substance can be avoided. Furthermore, the running of the filaments F can be stabilized to allow easy passage through the filament passage 25.

The gas suction device 60 can also be connected at the top of the spinning tube 20, to ensure that it can be lowered or lifted

together with the spinning tube 20. On the other hand, if the gas suction device 60 is separate from the spinning tube 20 and installed on the under face of the spinning block 11 or the spinneret 12, the clearance of the suction spaces 80 (Fig. 23) can be easily adjusted at a desired distance by lifting or lowering the spinning tube 20.

Then, a polymer is discharged from the spinning holes 13 arranged in a row in the spinneret 12 installed in the spinning block 11, to form numerous filaments F. The formed numerous filaments F pass through the filament passage 25 of the gas suction device 60 and the spinning tube 20. The running filaments F are solidified while they pass through the filament passage 25 of the spinning tube 20. Subsequently, the solidified filaments F are sucked by a suction gun (not illustrated), and guided along the oiling means 17, the first godet roller 14 and the second godet roller 15 sequentially, being finally wound by the winder 16. Thus, the initial work in the production of the yarn Y is completed.

Thereafter, the polymer is discharged continuously from the spinneret 12, to form numerous filaments F, and the formed numerous filaments F run downward in the filament passage 25 of the gas suction device 60 and the spinning tube 20 with their disposal maintained. During this time, the gas suction device 60 sucks the gas generated from the filaments F. In spite of the suction, the compressed air 41a injected from the injection holes 23a acts on the numerous filaments F running through the filament passage 25 of the spinning tube 20, and the numerous filaments F are aligned

along a straight line without overlapping each other. The numerous filaments F running in the filament passage 25 are cooled and solidified while they pass through the filament passage 25. The cooled and solidified numerous filaments F are bundled and oiled by the oiling means 17. The oiled numerous filaments F are guided as the yarn Y along the first godet roller 14 and the second godet roller 15, being wound around a bobbin by the winder 16. Thus, the yarn Y is produced as a yarn package.

This yarn production method satisfies both yarn quality and yarn productivity in good balance compared with the yarn production processes of the prior art. The yarn production process can also be used for producing a yarn consisting of numerous filaments composed of any of various polymers such as polypropylene and polylactic acid. This yarn production process can be used for producing a very thin yarn with a filament fineness of 0.5 dtex or less, or difficult in the control of yarn quality, and also for producing a thick yarn such as a monofilament.

A first group of Examples and Comparative Examples:

As examples of the yarn production method of the invention, yarn production methods using the yarn production apparatus shown in Fig. 4 are described below, and as comparative examples, yarn production methods using the apparatus shown in Fig. 1 are described. The production conditions used in the examples and comparative examples are shown in the following respective tables.

The spinning tube 20 used in Examples 1 through 13 is shown in Fig. 6. The cross sectional view of the spinning tube 20 and

its filament passage 25 is shown in Fig. 7. The cross sectional form of the filament passage 25 is rectangular. The spinning tube 20 had the air inlet section 22, the air injection section 23, the steady flow section 21 and the air discharge section 24, to name from the top end to the bottom end. The air inlet section 22 had a widened portion 22a, and the air discharge section 24 had a widened portion 24a. The length Ex of the short sides 21S in the cross section of the filament passage 25 in the steady flow section 21 was 2 mm, and the length Ey of the long sides 21L was 100 mm. The injection holes 23a open on the wall faces of the filament passage 25 respectively had a form of a slit extending over the full length of the long sides 21L of the filament passage 25. The slit width Ei (see Fig. 9) of the slits was 0.4 mm.

It is difficult to directly measure the injection velocity Vs (m/min) of the compressed air 41a injected from the injection holes 23a of the air injection section 23. Therefore, the value obtained by calculation from the injection flow rate Ef (m^3/min) of the compressed air 41a supplied from the blower of the air supply device 41, the cross sectional area of the passage of each injection hole 23a (Ey x Ei) and the supply pressure of the compressed air 41a was employed as the injection velocity Vs (m/min).

The running air stream velocity Ve (m/min) of the running air stream 40 flowing in the steady flow section 21 was obtained from the following formula based on the differential pressure Po between the respective pressures obtained from the pressure pipe P1 installed in the wall of the steady flow section 21 and the

pressure pipe P2 installed in the downstream region of the air discharge section 24.

$$Ve = (2 \cdot Po/\rho)^{1/2}$$

where ρ is the density of air.

The filament speed Vf (m/min) of the filaments F running between the spinneret 12 and the first godet roller 14 was measured using the measuring instrument shown in Fig. 32. In Fig. 32, a laser Doppler yarn velocimeter 50 consisted of a measuring head 51 and a controller 52. The measuring head 51 was moved in the running direction of the filaments F, and the filament speed Vf (m/min) of the filaments F running between the spinneret 12 and the first godet roller 14 was measured at every 100 mm position from the spinneret 12. To measure the filament speed of the filaments F running through the filament passage 25 in the spinning tube 20, the spinning tube 20 was partially opened at a portion corresponding to one short side 21b of the filament passage 25 so that the laser beam could reach the inside of the filament passage 25 from the measuring head 51 when the yarn speed was measured. In the case where the opening affects the air stream of the filament passage 25, the opening should be given up, and a small hole for allowing the transmission of the laser beam for measurement should be formed in the spinning tube 20 at a portion corresponding to one short side 21S of the filament passage 25. As another method, a portion of the spinning tube 20 corresponding to one short side 21S of the filament passage 25 should be made of a material capable of transmitting the laser beam for measurement, to allow

measurement through the portion.

In Fig. 4, L1 (mm) indicates the distance from the bottom face of the spinneret 12 to the top face of the spinning tube 20, and defines the spinning tube position. L2 (mm) indicates the overall length of the spinning tube 20, and defines the spinning tube length. L3 (mm) indicates the distance from the bottom face of the spinneret 12 to the oiling means 17, and defines the oiling position. L4 (mm) indicates the distance from the bottom face of the spinneret 12 to the first godet roller 14, and defines the take-up position. Vw (m/min) indicates the yarn Y take-up speed by the first godet roller 14. In Fig. 6, Es (mm) indicates the distance from the top face of the spinning tube 20 to the injection holes 23a of the air injection section 23 (the center of the open faces of the injection holes 23a in the vertical direction on the wall faces of the filament passage 25), and defines the slit position.

In the spinneret 12, the distance between the respectively adjacent spinning holes 13 is expressed as the spinning hole pitch P (mm), and the hole diameter of the spinning holes 13 on the bottom face of the spinneret 12 is expressed as the spinning hole diameter d (mm). The center distance between the two spinning holes most apart from each other among the plural spinning holes 13 is expressed as distance dw (mm) between the outermost spinning holes.

Examples 1, 2, 3 and 4

The apparatus shown in Fig. 4 was used to produce polyester yarns Y each consisting of 36 filaments F with a filament fineness

D of 135 dtex under the conditions shown in Table 1. The spinneret 12 used had all the spinning holes 13, i.e., 36 spinning holes 13 arranged on a straight line Z as shown in Fig. 5A. The spinning hole pitch P was 2.5 mm and the spinning hole diameter d was 0.3 mm. The distance dw between the outermost spinning holes was 90.3 mm. In Examples 1, 2, 3 and 4, the same conditions were employed except that the spinning tube position L1 was changed. The yarn production conditions and the properties of the obtained yarns are shown together in Table 1 given later.

In every example, the swing of the 36 filaments F running upstream and downstream of the spinning tube 20 was small, and a good spinning state could be observed. It was confirmed that the 36 filaments F maintained their disposal obtained immediately after they had been discharged from the spinneret 12, in the range from the upstream side of the spinning tube 20 to the outlet of the spinning tube 20, and passed through the spinning tube 20 without being converged (without contacting each other).

The results of yarn quality evaluation of the yarn Y wound by the winding means 16 are shown in Table 1. The yarn properties in Example 1 were 141% in elongation E, 2.4 g/dtex in strength T and 0.95 in yarn irregularity U%. Those in Example 2 were 128% in elongation E, 2.6 g/dtex in strength and 0.93 in yarn irregularity U%. Those in Example 3 were 104% in elongation E, 2.8 g/dtex in strength T and 1.00 in yarn irregularity U%. Those in Example 4 were 86% in elongation E, 3.0 g/dtex in strength T and 1.13 in yarn irregularity U%. There was a tendency that when the spinning

tube 20 was farther away from the spinneret 12, the elongation E of the obtained yarn Y was smaller while the yarn irregularity U% became larger.

The filament velocity Vf of the running filaments F was measured at every 100 mm position from the spinneret 12, and the results are shown in Fig. 33. The distance from the spinneret 12 to the point at which the solidified filaments F reached the take-up speed Vw was identified as the take-up speed reaching point Lg, and the distance from the spinneret 12 to the middle point between the two points of the largest gradients in the curve formed by connecting the measuring points was identified as the acceleration point. The results of these points in the respective examples are shown in Table 2 given later.

From Fig. 33, it can be seen that the position of the acceleration point La (acceleration points La1 to La4) shifted toward the downstream side as the value of the spinning tube position L1 became larger. It also can be seen that the position of each acceleration point La was on the upstream side of the one half of the distance to the corresponding reaching point Lg (reaching points Lg1 to Lg4). In Examples 1 through 4, the respective acceleration points La were 28%, 39%, 45% and 50% of the reaching points Lg. From the results, it was found that if the relation of acceleration point La ≤ reaching point Lg/2 is satisfied and the ratio of the acceleration point La to the reaching point Lg is lower, then the elongation E of the produced yarn Y becomes higher.

The temperature Ti (°C) of the filaments F at right above the air inlet section 22 of the spinning tube 20 was measured using a non-contact type thermometer in each example. The results are shown in Table 2. The temperatures Ti in the respective examples were 215°C in Example 1, 203°C in Example 2, 184°C in Example 3 and 158°C in Example 4. The results mean that if the value of the spinning tube position L1 is smaller, the filaments with a higher temperature enter the spinning tube 20.

While the filaments F are kept at a high temperature, the filaments F encounter the compressed air 41A injected obliquely downward toward the running direction of the filaments F from the injection holes 23a, and thereafter, together with the running air stream 40 running downward in the filament passage 25, the filaments run downward in the filament passage 25. The coexistence of the filaments F and the running air stream 40 allows the produced yarn Y to have a higher elongation. The yarn Y obtained like this can have an elongation of not less than 1.5 times the elongation of the yarn obtained in Comparative Example 1 described later.

In the relation between the spinning tube range Le (mm) in which the spinning tube 20 exists (the range from the bottom face of the spinneret 12 to L1 or L1 + L2) and the running air stream velocity Ve, as shown in Table 2, the respective acceleration points La are within the spinning tube range Le in Examples 1 through 4, and the values VL of the filament speed Vf at the acceleration points La are smaller than the values of the running air stream velocity Ve. This means that at least partially in the spinning

tube 20, the drawing force of the running air stream 40 acted on the filaments F.

Comparative Examples 1, 2 and 3

The apparatus shown in Fig. 1 was used to produce polyester yarns Y each consisting of 36 filaments F with a filament fineness D of 135 dtex under the conditions shown in Table 3. In the respective comparative examples, the spinneret 1 shown in Fig. 2 was used. The spinneret 1 had 36 spinning holes 6 so arranged within a circle having a diameter dd of 72 mm that the filaments discharged from the holes should not contact each other. The cooling means 3 shown in Fig. 1 supplied cooling air 3a to the downward running filaments F composed of a polymer discharged from the spinning holes 6 of the spinneret 1, in the direction perpendicular to the vertical direction. The filament cooling length L22 in the cooling means was 1,000 mm, and the cooling air velocity Vc1 of the cooling air 3a was 30 m/min. The cooling air 3a was blown from the cooling air blow face of the cooling means 3 and crossed the running filaments F, then being sent substantially in the same direction as the blow direction and discharged out of the cooling means 3. Therefore, there was no air stream that ran in the running direction of the filaments F and dominated the running filaments F.

In Fig. 1, L11 (mm) indicates the distance from the bottom face of the spinneret 1 to the top face of the cooling means 3, and defines the cooling means position. Comparative Examples 1, 2 and 3 employed the same conditions except that the yarn take-up

speed Vw was changed. The yarn production conditions and the properties of the obtained yarns in these comparative examples are shown together in Table 3 given later.

In every comparative example, the swing of the running 35 filaments upstream and downstream of the cooling means 3 was small. However, it was confirmed that the cooling air 3a crossing the filaments F in the direction substantially perpendicular to the running direction of the filaments F bent the running filaments F. The bending degree was different from filament to filament depending on the respective running positions resulting from the positions of the arranged spinning holes 6.

The results of yarn quality evaluation of the yarns Y wound by the winding means 5 are shown in Table 3. The yarn properties in Comparative Example 1 were 65% in elongation E, 3.1 g/dtex in strength T and 1.24 in yarn irregularity U%. Those in Comparative Example 2 were 98% in elongation E, 2.9 g/dtex in strength T and 1.13 in yarn irregularity U%. Those in Comparative Example 3 were 119% in elongation E, 2.7 g/dtex in strength T and 1.05 in yarn irregularity U%. It was confirmed that when the yarn take-up speed Vw was higher, the elongation E of the produced yarn was smaller.

In comparison with Examples 1 through 4, the examples could produce high strength yarns even at a yarn take-up speed Vw of 5,000 m/min. Especially Example 1 could produce a yarn with an elongation higher than that of Comparative Example 3 in which the take-up speed Vw was 3,500 m/min.

The filament speed Vf of the running filaments F was measured

at every 100 mm position from the spinneret 1, and the results are shown in Fig. 34. As in Example 1, the reaching points Lg and the acceleration points La are shown in Table 4 given later.

Fig. 34 shows that the increase of take-up speed Vw changed both the position of the reaching point Lg (reaching points Lg1x to Lg3x) and the position of the acceleration point (acceleration points La1x to La3x) toward the downstream side. However, the position of every acceleration point La was on the downstream side of one half of the distance to the position of the corresponding reaching point Lg. That is, the comparative examples showed a relation of acceleration point La > reaching point Lg/2 irrespective of the take-up speed Vw.

Example 5 and Comparative Example 4

In Example 5 and Comparative Example 4, the apparatus shown in Fig. 4 was used to produce polyester yarns each consisting of 36 filaments F with a filament fineness D of 135 dtex as described for Example 1, except that the injection flow rate Ef, the injection velocity Vs and the running air stream velocity Ve were changed as shown in Table 5 given later. The yarn production conditions and the properties of the obtained yarns in Example 5 and Comparative Example 4 are shown in Table 5 given later.

In Example 5, the swing of the running 36 filaments F in the positions upstream and downstream of the spinning tube 20 was small, and a good spinning state was observed. It was confirmed that the 36 filaments F maintained the disposal of filaments F as achieved immediately after having been discharged from the

spinneret 12, in the range from the upstream side of the spinning tube 20 to the outlet of the spinning tube 20, and that the filaments F passed through the spinning tube 20 without being converged (without contacting each other). On the other hand, in Comparative Example 4, probably because the drawing force of the running air stream 40 acting on the filaments F was insufficient due to the decrease of injection flow rate in the spinning tube 20, the disposal of the filaments F was disturbed, and it was confirmed that it happened especially in the upstream region of the spinning tube 20 and that the filaments F ran unstably.

The results of yarn quality evaluation of the yarns Y wound by the winding means 16 are shown in Table 5. The yarn properties in Example 1 were 141% in elongation E, 2.4 g/dtex in strength T and 0.95 in yarn irregularity U% at an injection velocity Vs of 6,000 m/min and a running air stream velocity Ve of 4,250 m/min. On the contrary, those in Example 5 were 112% in elongation E, 3.2 g/dtex in strength T and 1.01 in yarn irregularity U% at an injection velocity Vs of 4,900 m/min and a running air stream velocity Ve of 3,240 m/min. Further, on the contrary, those in Comparative Example 4 were 84% in elongation E, 3.5 g/dtex in strength T and 1.34 in yarn irregularity U% at an injection velocity Vs of 3,400 m/min and a running air stream velocity Ve of 1,980 m/min.

From these data, it can be seen that in the case where the injection velocity Vs and the running air stream velocity Ve are large, a yarn with a high elongation and small yarn irregularity

can be obtained.

It can also be seen that if the injection velocity Vs is higher than the take-up speed Vw, the amount sucked into the spinning tube 20 is stabilized, allowing a high quality yarn with a high elongation to be obtained.

On the other hand, it can be seen that if the injection velocity Vs is lower than the take-up speed, the amount sucked in the spinning tube 20 decreases, destabilizing the running of the filament F, hence causing yarn irregularity.

From these results and the results obtained in Examples 2 through 4, it can be seen that for producing a yarn with a high elongation, keeping the running air stream velocity Ve at not less than 60% of the take-up speed Vw is a desirable condition.

The filament speed Vf of the running filaments F at every 100 mm position from the spinneret was measured, and the results are shown in Fig. 35. As in Example 1, the reaching points Lg and the acceleration points La of Example 5 and Comparative Example 4 are shown in Table 6 given later.

In Fig. 35, in the case of Example 5, the position of the acceleration point La (acceleration point La5) was on the upstream side of one half of the distance to the position of the reaching point Lg (reaching point Lg5), but in the case of Comparative Example 4, the position of the acceleration point La (acceleration point La4x) was on the downstream side of one half of the distance to the position of the reaching point Lg (reaching point Lg4x). The results show that unless an air stream having an adequate injection

velocity Vs and running air stream velocity Ve satisfying the relation of the acceleration point La ≤ reaching point Lg/2 is given to the filaments F, a good quality yarn with a high elongation and small yarn irregularity cannot be obtained. As can be seen from Table 6, since the acceleration point La4x was positioned outside the spinning tube range Le, the running air stream velocity Ve did not effectively act on the filaments F in Comparative Example 4.

Examples 6 and 7

As shown in Table 7 given later, in Example 6, a polyester yarn consisting of 36 filaments F with a filament fineness D of 135 dtex was produced as described for Example 1, except that the steady flow section of the spinning tube 20 was extended to change the spinning tube length L2. On the other hand, in Example 7, a polyester yarn consisting of 36 filaments F with a filament fineness D of 135 dtex was produced as described for Example 6, except that the injection flow rate Ef and the injection velocity Vs were adjusted to ensure that the running air stream velocity Ve became virtually equal to that of Example 1 (6,200 m/min). The yarn production conditions and the properties of the obtained yarns in these examples are shown together in Table 7 given later.

In each example, the swing of the running 36 filaments F in the positions upstream and downstream of the spinning tube 20 was small, and a good spinning state was observed. It was confirmed that the 36 filaments F maintained the disposal of the filaments F as achieved immediately after having been discharged from the

spinneret 12, in the range from the upstream side of the spinning tube 20 to the outlet of the spinning tube 20, and that the filaments F passed through the spinning tube 20 without being converged (without contacting each other).

The results of yarn quality evaluation of the yarns Y wound by the winding means 16 are shown in Table 7.

The yarn properties of Example 6 were 128% in elongation E, 2.7 g/dtex in strength T and 0.80 in yarn irregularity U% at a running air stream velocity Ve of 3,680 m/min. Compared with Example 1, the value of yarn irregularity U% was improved. However, though the injection flow rate Ef was equivalent to that of Example 1, it is considered that the pressure resistance caused by the longer steady flow section 21 lowered the running air stream velocity Ve and also decreased the sucked flow 42a of the spinning tube 20, to lower the total flow rate of the running air stream 40, thus lowering the running air stream velocity Ve and lowering the elongation of the obtained yarn.

The yarn properties of Example 7 were 140% in elongation E, 2.4 g/dtex in strength T and 0.82 in yarn irregularity U% at a running air stream velocity Ve of 4,200 m/min. Compared with Example 1, the elongation E was equivalent and the yarn irregularity U% was better. These results suggest that a longer spinning tube length L2 can inhibit the disturbance of the filaments F running in the spinning tube 20, and that a running air stream velocity Ve equivalent to or higher than the take-up speed Vw is a factor capable of greatly improving the elongation of the yarn. These

effects can also be obtained by adjusting the length of the bottom end section 24N of the spinning tube 20 of Fig. 9.

Examples 8, 9 and 10

The spinneret 12 used in Example 8 had numerous spinning holes 13 arranged in two straight lines Z1 and Z2 as shown in Fig. 5B. The length Ey of the long sides 21L in the cross section of the steady flow section 21 of the spinning tube 20 was changed to one half of the Ey value of Example 1. Furthermore, the same yarn production apparatus as used in Example 1 was used except that the injection flow rate Ef and the injection velocity Vs were adjusted to achieve a running air stream velocity Ve equivalent to that of Example 1. Polyester yarns each consisting of 36 filaments F with a filament fineness D of 135 dtex were produced.

In Examples 9 and 10, polyester yarns each consisting of 36 filaments F with a filament fineness D of 135 dtex were produced as described for Example 8, except that the injection angle θ of the injection holes 23a in the spinning tube 20 was changed as shown in Table 8 given later. The yarn production conditions and the properties of the obtained yarns in these examples are shown together in Table 8 given later.

In each example, the swing of the running 36 filaments F in the positions upstream and downstream of the spinning tube 20 was small, and a good spinning state was observed. It was confirmed that the 36 filaments F maintained the disposal of the filaments F as achieved immediately after having been discharged from the spinneret 12, in the range from the upstream side of the spinning

tube 20 to the outlet of the spinning tube 20, and that the filaments F passed through the spinning tube 20 without being converged (without contacting each other).

A yarn was produced under the same conditions as in Example 8, except that the spinneret used had the spinning holes 13 arranged in straight lines Z1 and Z2 to overlap each other on the projection drawing of the spinneret, in an attempt to evaluate the yarn similarly. However, in this case, a phenomenon occurred, in which the filaments F entering the spinning tube 20 fused each other in the upstream region of the spinning tube 20. Since filament breaking and fluffing occurred in the yarn, the yarn was not taken up for evaluation.

The results of yarn quality evaluation of the yarns Y wound by the winding means 16 are shown in Table 8. The yarn properties of Example 8 were 140% in elongation E, 2.4 g/dtex in strength T and 0.98 in yarn irregularity U%. It was found that a yarn with the same quality as that of Example 1 was obtained. It was confirmed that even in the case where the spinneret 12 has spinning holes 13 arranged in two rows, if the spinning holes 13 are positioned to avoid overlapping in the direction perpendicular to the respective straight lines Z1 and Z2, the intended yarn could be produced without any problem.

If a spinneret having the spinnerets 13 arranged in plural rows is employed, the length Ey of the long sides of the filament passage 25 of the spinning tube 20 can be shortened. In the case where the spinning holes are arranged in two rows, the length Ey

becomes about one half of the length needed when they are arranged in one row, if the number of filaments F and the filament fineness D are identical. In this case, the injection flow rate Ef can be decreased to reduce the production cost needed for compressed air consumption.

In Examples 9 and 10 where the injection angle θ was changed, the running air stream velocity Ve increased when the injection angle θ was made sharper, compared with that in Example 8. It is considered that if the injection angle θ is smaller, the sucked flow 42a entering from the inlet of the filament passage 25 of the spinning tube 20 increases to increase the flow rate of the running air stream 40.

The properties of the wound yarns were evaluated. Those of Example 9 were 143% in elongation E, 2.4 g/dtex in strength T and 0.91 in yarn irregularity U% at a running air stream velocity Ve of 4,780 m/min. Those of Example 10 were 145% in elongation E, 2.3 g/dtex in strength T and 0.88 in yarn irregularity U% at a running air stream velocity Ve of 5,230 m/min. That is, it was confirmed that if the injection angle θ is smaller, a good quality yarn with an elongation equivalent or higher than that of Example 9 could be obtained.

Example 11

A polyester yarn consisting of 36 filaments F with a filament fineness D of 135 dtex was produced as described for Example 1 under the conditions shown in Table 9 given later, except that an apparatus as shown in Fig. 12 was used, in which flow regulation

sections 31 having air regulation plates were installed upstream of the spinning tube 20. The air regulating boards were honeycomb grates installed on both sides of the filaments F at a position immediately above the air inlet section 22 of the spinning tube 20. The size of each flow regulation section 31 was 60 mm in length Lc and 10 mm in thickness Lt. The yarn production conditions and the properties of the obtained yarn of Example 11 are shown together in Table 9 given later.

In Example 11, the swing of the running 36 filaments F in the positions upstream and downstream of the spinning tube 20 was small, and a good spinning state was observed. It was confirmed that the 36 filaments F maintained the disposal of the filaments F as achieved immediately after having been discharged from the spinneret 12, in the range from the upstream side of the spinning tube 20 to the outlet of the spinning tube 20, and that the filaments F passed through the spinning tube 20 without being converged (without contacting each other).

The yarn properties of the wound yarn Y were evaluated and found to be 143% in elongation E, 2.4 g/dtex in strength T and 0.85 in yarn irregularity U%. Compared with Example 1, since the air regulation plates regulated the sucked flow 42a, it could be visually confirmed that the swing of the filaments F in the position upstream of the spinning tube 20 was smaller than that in Example 1, and that because of it, the yarn irregularity could be further improved.

Examples 12 and 13

Polyester yarns each consisting of 36 filaments F with a filament fineness D of 135 dtex were produced under the conditions shown in Table 10 given later, as described for Example 1, except that, as shown in Fig. 15, a block-shaped temperature regulation pipe 37 for controlling the temperature of the filaments F was installed upstream of the spinning tube 20, to adjust the temperature TH of the temperature regulation section in the temperature regulation passage 35a at 250°C. The cross sectional form of the temperature regulation passage 35a of the temperature regulation pipe 37 was rectangular, and the length LH of the temperature regulation section as the length of the temperature regulation pipe 37 in the running direction of the filaments F was 60 mm. Ceramic heaters were installed as heating members 36 in the long side direction 37a of the rectangular temperature regulation passage 35a. The yarn production conditions and the properties of the obtained yarns in these examples are shown together in Table 10 given later.

In each example, the swing of the running 36 filaments F in the positions upstream and downstream of the spinning tube 20 was small, and a good spinning state was observed. It was confirmed that the 36 filaments F maintained the disposal of the filaments as achieved immediately after having been discharged from the spinneret 12, in the range from the upstream side of the spinning tube 20 to the outlet of the spinning tube 20, and that the filaments F passed through the spinning tube 20 without being converged (without contacting each other).

The yarn properties of the wound yarns Y were evaluated. Those of Example 12 with the running air stream velocity Ve set at 4,250 m/min were 153% in elongation E, 2.2 g/dtex in strength T and 0.95 in yarn irregularity U%. Compared with Example 1, the winding speed was equal, but a yarn having a higher elongation could be obtained.

Those of Example 13 with the running air stream velocity set at 3,200 m/min were 140% in elongation E, 2.4 g/dtex in strength T and 0.92 in yarn irregularity U%. Even if the injection flow rate Ef was lowered, a yarn with the same quality as that of Example 1 could be obtained since the temperature regulation means 35 was used.

As in Example 12, the temperature Ti of the filaments F in the position upstream of the spinning tube 20 was measured and found to be 227°C. The temperature Ti in Example 1 was 215°C as shown in Table 2, and this value was lower than those of Examples 12 and 13. This means that if the temperature of the filaments F before they enter the spinning tube 20 is kept at a high temperature, an equivalent elongation E can be obtained even if the running air stream velocity Ve in the spinning tube 20 is lowered. Therefore, since the injection flow rate Ef can be decreased, the yarn production cost can be reduced.

Comparative Example 5

The apparatus used in Comparative Example 5 was the same as the apparatus shown in Fig. 1 used in Comparative Example 1, except that a cylindrical air stream forming section 70 consisting

of a cylindrical cooling means 55, a funnel-shaped acceleration section 72 and a tube 73 shown in Fig. 3 was installed instead of the cooling means 3, in which the cooling air 55a was sent to the tube 73 for generating a parallel stream 73a in parallel to the running direction of the filaments F in the tube 73. The cylindrical air stream forming section 70 had the following dimensions: the distance LD from the spinneret 1 to the cylindrical cooling means 55 (spinneret depth) was 25 mm; the length LP of the cylindrical cooling means 55 in the vertical direction (cooling cylinder length) was 300 mm; the angle of the funnel-shaped acceleration section 74 (acceleration taper angle) was 60°; the length LR of the funnel-shaped acceleration section in the vertical direction (acceleration length) was 55 mm; the length LN of the tube 73 (tube length) was 450 mm; and the tube diameter dl was 25 mm. The apparatus was the same as that of Comparative Example 1, except the cylindrical air stream forming section 70.

This apparatus was used to produce a polyester yarn consisting of 36 filaments F with a filament fineness D of 135 dtex under the conditions shown in Table 11 given later. The cooling air was supplied to the cylindrical cooling means 55 to achieve a cooling air velocity Vc of 30 m/min, and in this case, it was confirmed that the air velocity Vt in the tube 73 was 2,200 m/min. The yarn production conditions and the properties of the obtained yarn in Comparative Example 5 are shown together in Table 11 given later.

The yarn properties of the wound yarn of Comparative Example

5 were evaluated and found to be 108% in elongation E, 2.9 g/dtex in strength T and 1.22 in yarn irregularity U%.

The yarn produced in Comparative Example 5 was larger in the value of yarn irregularity U% than in the examples in conformity with the invention, though it could be improved in the value of elongation E. The yarn production apparatus used in Comparative Example 5 was found to be likely to cause yarn irregularity.

Since the yarn was whirled and the filaments F crossed each other at the outlet of the tube 73, it was confirmed that the filaments F (yarn Y) were disturbed and unstable in running. The reason is that the passage through which the filaments F ran had a cylindrical form. This phenomenon does not occur in the yarn production method and apparatus of the invention, in which the spinning holes of the spinneret are arranged along a straight line and in which the cross sectional form of the filament passage of the spinning tube is rectangular. The cooling air velocity Vc was raised to raise the air velocity Vt in the tube, but the higher cooling air velocity Vc caused the discharged numerous filaments F composed of a polymer to be converged at the center and fused each other, not being able to be taken up as a yarn Y.

A second group of Examples and Comparative Examples:

The apparatus shown in Fig. 19 was used to produce a polyester yarn for evaluation. The yarn production conditions are shown in Table 12 given later. The yarn production state was evaluated for 36 hours after start of yarn production. During this period, the running state of the filaments F was observed adequately, and

the produced yarn was sampled every 12 hours, for evaluating the yarn properties. The production of the yarn was stopped 36 hours after start of production. When the production of the yarn was stopped, the state of the filament passage 25 in the spinning tube 20 was observed.

The spinning tube 20 used in Example 14 is shown in Figs. 6 and 7. The cross sectional form of the filament passage 25 was rectangular. The air inlet section 22 had a widened portion 22a. The air discharge section 24 had a widened portion 24a. The length Ex of the short sides of the rectangle as the cross sectional form of the filament passage 25 in the steady flow section 21 was 2 mm, and the length Ey of the long sides was 100 mm. The injection holes 23a open on the wall faces of the filament passage 25 were formed as slits. The slits were open over the entire length of the long sides 21L of the rectangle as the cross sectional form of the filament passage 25. The slit width Ei (see Fig. 9) of the slits was 0.4 mm.

For the suction gas velocity SV occurring at each gas suction port 62 of the gas suction device 60, the correlation between the values indicated by the pressure gauge 67 and the achieved gas velocities was measured beforehand, to obtain the value of the suction gas velocity SV. The numerous filaments F were guided to run downward at the center between the gas suction ports 62 installed on both sides of the filaments. The distance between each gas suction port 62 and the filaments F (suction distance PL) was set at 1/2 of the distance between both the gas suction

ports 62.

For the suction spaces 80 provided between the gas suction device 60 and the spinning tube 20 as shown in Fig. 23, honeycomb grate members (thickness 15 mm, grate pitch 3 mm) were used and installed on both sides of the numerous filaments F in parallel with them. Like the gas suction device 60, side plates 68 were used to close the faces in the short side direction against the outside (see Fig. 22).

In Fig. 19, SL (mm) indicates the distance from the bottom face of the spinneret 12 to the top face of the gas suction device 60, and defines the space below the nozzle. BL (mm) indicates the length of the gas suction device 60 in the vertical direction, and defines the suction region. AL (mm) indicates the length of the suction spaces 80 (see Fig. 23) from the bottom face of the gas suction device 60 to the top face of the spinning tube 20 in the vertical direction, and defines the ventilation distance.

In Fig. 18, L1 (mm) indicates the distance from the bottom face of the spinneret 12 to the top face of the spinning tube 20, and defines the spinning tube position. L2 (mm) indicates the overall length of the spinning tube 20 and defines the spinning tube length. L3 (mm) indicates the distance from the bottom face of the spinneret 12 to the oiling means 17 and defines the oiling position. L4 (mm) indicates the distance from the bottom face of the spinneret to the first godet roller 14, and defines the take-up position. Vw (m/min) indicates the yarn Y take-up speed by the first godet roller 14, and defines the take-up speed. In

Fig. 6, Es (mm) indicates the distance from the top face of the spinning tube 20 to the injection holes 23a of the air injection section 23 (the center of the open faces of the injection holes 23a in the vertical direction on the wall faces of the filament passage 25), and defines the slit position.

For the spinneret 12, the distance between the respectively adjacent spinning holes 13 is called the spinning hole pitch P (mm), and the hole diameter of the spinning holes 13 on the bottom face of the spinneret 12 is called the spinning hole diameter d (mm). The center distance between the two spinning holes most apart from each other among the plural spinning holes 13 is called the distance dw (mm) between the outermost spinning holes.

Example 14

The apparatus of Fig. 19 was used to produce a polyester yarn (PET yarn) consisting of 36 filaments F with a filament fineness D of 135 dtex under the conditions shown in Table 12 given later at a speed of 5,000 m/min. The spinneret 12 used had all the numerous spinning holes arranged in a straight line Z as shown in Fig. 5A. The spinning hole pitch P was 2.5 mm, the spinning hole diameter d was 0.3 mm, and the distance dw between the outermost spinning holes was 87.5 mm.

Example 15 and Comparative Example 6

Example 15 and Comparative Example 6 were carried out under the same conditions, except that the gas suction velocity SV was changed. The yarn properties of the yarns sampled after lapse of predetermined times are shown in Table 13. The evaluated yarn

properties were strength T, elongation E, yarn irregularity U% and fluff K. Table 13 also shows the results of the inner face of the filament passage 25 of the spinning tube 20 observed 36 hours after start of yarn production.

To measure the strength T and elongation E, a test yarn with a length of 50 mm cut from a produced yarn (multifilament) was stretched at a tensile speed of 400 mm/min till it was broken using a general tensile tester. To measure the yarn irregularity U%, Uster Tester 1 Model C produced by Zellweger Co., Ltd. was used, and a yarn was supplied at a speed of 100 m/min for measuring in the normal mode. To measure the fluff K, a fly counter produced by Toray Engineering Co., Ltd. was used to count the number of fluffy pieces in a measuring length of 12,000 m at a speed of 400 m/min.

In each of Example 14 and 15, the swing of filaments F was small throughout the yarn production period, and a good spinning state was maintained. It was confirmed that the numerous filaments F maintained the disposal of the filaments as achieved immediately after having been discharged from the spinneret 12, in the range from the spinneret 12 to the outlet of the spinning tube 20, and that the filaments passed through the spinning tube 20 without being converged (without contacting each other). The yarn properties of the wound yarns were evaluated. As shown in Table 13, the yarn irregularity U% values in Example 14 were 0.85 after lapse of 12 hours, 0.88 after lapse of 24 hours and 0.84 after lapse of 36 hours, and those in Example 15 were 0.83 after lapse

of 12 hours, 0.80 after lapse of 24 hours and 0.82 after lapse of 36 hours. On the whole, the fluff of yarns was not observed. Thirty six hours after start of yarn production, the yarn production was stopped, and the spinning tube 20 was dismantled, to inspect the deposition of the volatile matter onto the filament passage 25. The deposition of the volatile substance was substantially not observed, and the filament passage was little contaminated and kept in a good state.

On the other hand, in Comparative Example 6 in which the gas suction device 60 was not used for suction, the filaments F entering the spinning tube 20 began to swing after lapse of about 18 hours, and it was observed that the swing became large after lapse of about 30 hours. The yarn irregularity U% of the obtained yarn became worse with the lapse of time. Though no fluff existed in the yarn sampled immediately after start of yarn production, the fluff of the sampled yarn increased with the lapse of time. After lapse of 36 hours, the filament passage 25 of the spinning tube 20 was observed, and it was found that a large amount of a deposit like white powder had been deposited, and that the air injection section 23 had been partially clogged. The deposit was examined by means of chromatography, and it was confirmed that the main component was hydroxyethyl terephthalate sublimed from the polyester.

The examples used polyethylene terephthalate yarns (PET yarns) only since they are typical polyester yarns, but in the invention, the polymer used is not especially limited. For example,

also in the production of yarns of polyamide, polypropylene and aliphatic polyesters (polylactic acid, etc.), similar effects can be obtained. The yarn production method and apparatus can be especially preferably applied to a polylactic acid yarn, since it generates a large amount of a volatile matter.

Table 1

Item	Unit	Example 1	Example 2	Example 3	Example 4
Vw: Take-up speed	m/min	5,000	Ditto	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto	Ditto
L2: Spinning tube length	mm	300	Ditto	Ditto	Ditto
Ey: Length of long sides of passage	mm	100	Ditto	Ditto	Ditto
Ex: Length of short sides of passage	mm	2	Ditto	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	Ditto	Ditto
Ei: Injection slit width	mm	0.4	Ditto	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto	Ditto
L1: Spinning tube position	mm	100	200	300	400
L3: Oiling means position	mm	1,500	Ditto	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto	Ditto
Ef: Injection flow rate	m^3/min	0.5	Ditto	Ditto	Ditto
Vs: Injection velocity	m/min	6,000	Ditto	Ditto	Ditto
Ve: Running air stream velocity	m/min	4,250	Ditto	Ditto	Ditto
T: Strength	g/dtex	2.4	2.6	2.8	3.0
E: Elongation	%	141	128	104	86
U%: Yarn irregularity	U value	0.95	0.93	1.00	1.13

Table 2

Item	Unit	Example 1	Example 2	Example 3	Example 4
Lg: Take-up speed reaching position	mm	900	900	1,000	1,100
La: Maximum acceleration position	mm	250	350	450	550
Ti: Filament temperature	℃	215	203	184	158
VL: Filament speed at maximum acceleration position	m/min	1,800	2,200	2,400	2,500
Le: Spinning tube range					
L1:	mm	100	200	300	400
L1 + L2	mm	400	500	600	700

Table 3

Item	Unit	Comparative Example 1	Comparative Example 2	Comparative Example 3
Vw: Take-up speed	m/min	5,000	4,000	3,500
D: Fineness	dtex	135	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto
L22: Cooling length	mm	1,000	Ditto	Ditto
EY: Cooling section width	mm	200	Ditto	Ditto
L11: Cooling means position	mm	80	Ditto	Ditto
L33: Oiling means position	mm	1,500	Ditto	Ditto
L44: Take-up position	mm	3,200	Ditto	Ditto
Vcl: Cooling air velocity	m/min	30	Ditto	Ditto
T: Strength	g/dtex	3.1	2.9	2.7
E: Elongation	%	65	98	119
U%: Yarn irregularity	U value	1.24	1.13	1.05

Table 4

Item	Unit	Comparative Example 1	Comparative Example 2	Comparative Example 3
Lg: Take-up speed reaching position	mm	700	900	800
La: Maximum acceleration position	mm	650	550	450

Table 5

Item	Unit	Example 1	Example 5	Comparative Example 4
Vw: Take-up speed	m/min	5,000	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto
L2: Spinning tube length	mm	300	Ditto	Ditto
Ey: Length of long sides of passage	mm	100	Ditto	Ditto
Ex: Length of short sides of passage	mm	2	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	Ditto
Ei: Injection slit width	mm	0.4	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto
L1: Spinning tube position	mm	100	Ditto	Ditto
L3: Oiling means position	mm	1,500	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto
Ef: Injection flow rate	m^3/min	0.5	0.4	0.3
Vs: Injection velocity	m/min	6,000	4,900	3,400
Ve: Running air stream velocity	m/min	4,250	3,240	1,980
T: Strength	g/dtex	2.4	3.2	3.5
E: Elongation	%	141	112	84
U%: Yarn irregularity	U value	0.95	1.01	1.34

Table 6

Item	Unit	Example 1	Example 5	Comparative Example 4
Lg: Take-up speed reaching position	mm	900	1,000	1,000
La: Maximum acceleration position	mm	250	350	650
VL: Filament speed at maximum acceleration position	m/min	1,800	2,300	3,500
Le: Spinning tube range				
L1:	mm	100	100	100
L1 + L2	mm	400	400	400

Table 7

Item	Unit	Example 1	Example 6	Example 7
Vw: Take-up speed	m/min	5,000	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto
L2: Spinning tube length	mm	300	900	900
Ey: Length of long sides of passage	mm	100	Ditto	Ditto
Ex: Length of short sides of passage	mm	2	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	Ditto
Ei: Injection slit width	mm	0.4	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto
L1: Spinning tube position	mm	100	Ditto	Ditto
L3: Oiling means position	mm	1,500	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto
Ef: Injection flow rate	m^3/min	0.5	Ditto	0.6
Vs: Injection velocity	m/min	6,000	Ditto	6,600
Ve: Running air stream velocity	m/min	4,250	3,680	4,200
T: Strength	g/dtex	2.4	2.7	2.4
E: Elongation	%	141	128	140
U%: Yarn irregularity	U value	0.95	0.80	0.82

Table 8

Item	Unit	Example 1	Example 8	Example 9	Example 10
Vw: Take-up speed	m/min	5,000	Ditto	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto	Ditto
W: Spinning hole row pitch	mm	--	2.5	2.5	2.5
L2: Spinning tube length	mm	300	Ditto	Ditto	Ditto
Ey: Length of long sides of passage	mm	100	50	50	50
Ex: Length of short sides of passage	mm	2	Ditto	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	10	5
Ei: Injection slit width	mm	0.4	Ditto	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto	Ditto
L1: Spinning tube position	mm	100	Ditto	Ditto	Ditto
L3: Oiling means position	mm	1,500	Ditto	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto	Ditto
Ef: Injection flow rate	m^3/min	0.5	0.25	0.25	0.25
Vs: Injection velocity	m/min	6,000	5,900	5,900	5,900
Ve: Running air stream velocity	m/min	4,250	4,190	4,780	5,230
T: Strength	g/dtex	2.4	2.4	2.4	2.3
E: Elongation	%	141	140	143	145
U%: Yarn irregularity	U value	0.95	0.98	0.91	0.88

Table 9

Item	Unit	Example 1	Example 11
Vw: Take-up speed	m/min	5,000	Ditto
D: Fineness	dtex	135	Ditto
F: Number of filaments	Number	36	Ditto
d: Spinning hole diameter	mm	0.3	Ditto
P: Spinning hole pitch	mm	2.5	Ditto
Lc: Air regulation plate length	mm	--	60
Lt: Air regulation plate thickness	mm	--	10
L2: Spinning tube length	mm	300	Ditto
Ey: Length of long sides of passage	mm	100	Ditto
Ex: Length of short sides of passage	mm	2	Ditto
θ: Injection angle	degrees	15	Ditto
Ei: Injection slit width	mm	0.4	Ditto
Es: Injection slit position	mm	50	Ditto
L1: Spinning tube position	mm	100	Ditto
L3: Oiling means position	mm	1,500	Ditto
L4: Take-up position	mm	3,200	Ditto
Ef: Injection flow rate	m^3/min	0.5	Ditto
Vs: Injection velocity	m/min	6,000	Ditto
Ve: Running air stream velocity	m/min	4,250	Ditto
T: Strength	g/dtex	2.4	2.4
E: Elongation	%	141	143
U%: Yarn irregularity	U value	0.95	0.85

Table 10

Item	Unit	Example 1	Example 12	Example 13
Vw: Take-up speed	m/min	5,000	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto
LH: Temperature regulation section length	mm	--	60	60
TH: Temperature regulation section temperature	℃	--	250	250
L2: Spinning tube length	mm	300	Ditto	Ditto
Ey: Length of long sides of passage	mm	100	Ditto	Ditto
Ex: Length of short sides of passage	mm	2	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	Ditto
Ei: Injection slit width	mm	0.4	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto
L1: Spinning tube position	mm	100	Ditto	Ditto
L3: Oiling means position	mm	1,500	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto
Ef: Injection flow rate	m^3/min	0.5	Ditto	0.4
Vs: Injection velocity	m/min	6,000	Ditto	4,500
Ve: Running air stream velocity	m/min	4,250	Ditto	3,200
T: Strength	g/dtex	2.4	2.2	2.4
E: Elongation	%	141	153	140
U%: Yarn irregularity	U value	0.95	0.95	0.92

Table 11

Item	Unit	Comparative Example 5
Vw: Take-up speed	m/min	5,000
D: Fineness	dtex	135
F: Number of filaments	Number	36
d: Spinning hole diameter	mm	0.3
LP: Cooling tube length	mm	300
d1: Tube diameter	mm	25
θ1: Acceleration taper angle	degrees	60
Lb: Tube length	mm	450
LR: Acceleration length	mm	55
L3: Oiling means position	mm	1,500
L4: Take-up position	mm	3,200
Vc: Cooling air velocity	m/min	30
Vt: Tube air velocity	m/min	2,200
T: Strength	g/dtex	2.9
E: Elongation	%	108
U%: Yarn irregularity	U value	1.22

Table 12

Item	Unit	Example 14	Example 15	Comparative Example 6
Vw: Take-up speed	m/min	5,000	Ditto	Ditto
D: Fineness	dtex	135	Ditto	Ditto
F: Number of filaments	Number	36	Ditto	Ditto
d: Spinning hole diameter	mm	0.3	Ditto	Ditto
P: Spinning hole pitch	mm	2.5	Ditto	Ditto
TP: Nozzle temperature	℃	285	Ditto	Ditto
SL: Space below nozzle	mm	5	Ditto	Ditto
BL: Suction region	mm	45	Ditto	Ditto
AL: Ventilation distance	mm	50	Ditto	Ditto
Sv: Suction gas velocity	m/min	10	30	0
PL: Suction distance	mm	10	Ditto	Ditto
L2: Spinning tube length	mm	300	Ditto	Ditto
Ey: Length of long sides of passage	mm	100	Ditto	Ditto
Ex: Length of short sides of passage	mm	2	Ditto	Ditto
θ: Injection angle	degrees	15	Ditto	Ditto
Ei: Injection slit width	mm	0.4	Ditto	Ditto
Es: Injection slit position	mm	50	Ditto	Ditto
L1: Spinning tube position	mm	100	Ditto	Ditto
L3: Oiling means position	mm	1,500	Ditto	Ditto
L4: Take-up position	mm	3,200	Ditto	Ditto
Vs: Injection velocity	m/min	6,000	Ditto	Ditto
Ve: Running air stream velocity	m/min	4,250	Ditto	Ditto

Table 13

	Item	Unit	Example 14	Example 15	Comparative Example 6
After lapse of 12 hours	T: Strength	g/dtex	2.5	2.6	2.4
	E: Elongation	%	135	136	130
	U%: Yarn irregularity	U value	0.85	0.83	1.00
	K: Number of fluff pieces	Number /12km	0	0	0
After lapse of 14 hours	T: Strength	g/dtex	2.5	2.6	2.4
	E: Elongation	%	135	136	130
	U%: Yarn irregularity	U value	0.88	0.80	1.10
	K: Number of fluff pieces	Number /12km	0	0	18
After lapse of 36 hours	T: Strength	g/dtex	2.5	2.6	2.4
	E: Elongation	%	135	136	130
	U%: Yarn irregularity	U value	0.84	0.82	1.14
	K: Number of fluff pieces	Number /12km	0	0	67
Result of confirmation of contamination after lapse of 36 hours			Little	Little	Much

Industrial Applicability

The yarn production method and apparatus of the invention use a spinneret having numerous spinning holes arranged at a desired pitch as a row or plural rows in a straight line(s), a spinning tube (ejector) having a filament passage through which a row(s) of numerous filaments composed of a polymer discharged from the spinning holes and running downward from the spinneret pass(es), an oiling means for applying an oiling agent to the numerous

filaments coming out of the spinning tube, a take-up means for taking up the oiled numerous filaments, and a yarn winding means for winding the numerous filaments coming from the take-up means, wherein in the filament passage of the spinning tube, air is injected obliquely downward toward the numerous filaments disposed in the row direction of the spinning holes and entering the filament passage, from both sides of the disposal of the numerous filaments, to dispose the numerous filaments in one row without allowing them to overlap each other, and the air stream formed as a confluence of the air streams injected obliquely downward from both sides and running downward in the filament passage acts on the disposed numerous filaments running downward in the filament passage for drawing them, to make them thinner, before the polymer constituting the filaments is solidified; in this yarn production process, since the velocity of the air stream running downward in the filament passage is not less than 60% of the take-up speed of the numerous filaments taken up by the take-up means or since the gas generated from the numerous filaments is sucked and discharged outside in the range between the spinneret and the spinning tube, a yarn with a high elongation can be wound by a yarn winding means even if the yarn take-up speed of the take-up means is high. The obtained yarn is small in the irregularity between filaments. Even in the case where the width of the filament passage in the direction perpendicular to the direction in which the numerous filaments are disposed side by side is small, since the gas generated from the numerous filaments in the range between the spinneret and the

spinning tube is sucked and discharged outside, it can be prevented that the volatile substance of the filaments contaminates the filament passage having a narrow width. So, a stable yarn can be continuously produced without suspension of yarn production.